# Establishing Priorities for the Public Good Science Fund

*A Discussion Document*

**Science Priorities Review Panel**

**(SPiR)**

**24 March 1995**

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## PREFACE

This discussion document has been produced by the Science Priorities Review Panel (known as SPiR) as part of the process of reviewing priorities for the Public Good Science Fund (PGSF). The 1995 review is the first to be carried out since priorities were set in 1992. The SPiR has been charged with developing advice on:

- the distribution of the PGSF across 17 outputs;
- definition of Key Science Areas (KSAs); and
- other non-quantitative guidelines for investment.

This advice is required to be aligned with the strategic goals and directions stated in "Science & Technology: The Way Forward 1996-2001", The Government's Strategic Statement to Guide Investment through the Public Good Science Fund.

The SPiR has arrived at its initial views on all of these matters, and is now seeking comment on them from individuals and organisations with an interest in the future of research, science and technology in New Zealand.

Submissions on this document should aim to assist the SPiR to arrive at its final advice to the Government. The SPiR is interested in hearing views which address the issues, assessment and results contained in the document, and intends to allow a period of six weeks to allow for responses to be prepared. During that time, members of the SPiR will also attend a number of public meetings to enable dialogue about priorities to take place.

Information about the public meetings can be obtained by contacting the Ministry of Research, Science and Technology at (04) 472 6400.

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**By 8 May 1995**

## EXECUTIVE SUMMARY

The Science Priorities Review Panel (known as SPiR) was appointed by the Government in December 1994 to oversee the second principal phase of the overall process of setting priorities for the Public Good Science Fund (PGSF) for the five-year period from 1996/97 to 2000/01. The context for the SPiR's task had already been established by the work of the Strategic Consultative Group on Research (SCGR) and "Science & Technology: The Way Forward", the Government's Strategic Statement to Guide Investment through the PGSF.

The SPiR has consulted widely within the science provider and user communities in developing the content of this discussion paper. A significant element of the overall consultation has been incorporation of the outcomes of a parallel process of consulting with Maori, carried out by the Ministry of Research, Science and Technology.

In considering output funding levels, the panel has developed the two "bounding" funding scenarios required by its terms of reference and also a third, intermediate scenario. The three scenarios are for total funding levels in the year 2000-01 (five years out from the year in which the priorities will first apply) of $290M, $330M and $370M. It is stressed that none of these scenarios is considered likely, although the panel's commentary is for the intermediate scenario and table one shows the recommended output funding levels for this scenario.

The SPiR used a mix of methodologies to arrive at its views on output funding levels. These different approaches were used in order to test the robustness of the answers generated. As a result, the panel is confident that the directions it has determined are sound and consistent with the goals set by the Government in its Strategic Statement.

The most significant trends are towards increasing support for environmental, social and infrastructural research and a rebalancing of effort within the economic outputs. The full tables showing recommended changes are shown in the Executive Summary and in Chapter Seven.

The panel was also required to identify Key Science Areas (KSAs) of long term importance to New Zealand. In doing so, it has sought the assistance of an expert working group, appointed in consultation with the Royal Society, to develop a list of potential KSAs. The list of these KSAs is contained in Chapter Nine, and full descriptions are in Annex Five.

The broad guidelines for PGSF allocations, contained within the Government's Strategic Statement, have been further developed by the SPiR and are set down in Chapter Ten. Additional elements over those set out in the Strategic Statement are the treatment of cross-output themes and support for science databases and collections.

The final Chapter invites comments on the future development of priorities. Issues raised include the creation of an underpinning analytical framework to support analysis of the 17 outputs and further development of quantitative methodologies.

Submissions are now being sought on this discussion document, to enable the SPiR to develop its final report to Government. Details of how to make submissions are contained

in the preface. The final act in the process will be the Government's release of a priority statement to guide the Foundation for Research, Science and Technology in allocating the PGSF for the five years from 1996/97.

**Table One: Output Funding Levels for 2000 - 2001: $330M Scenario**

| Output Titles | 1995-96 funding (estimated $M) | Recommended funding 2000-01 | % change in funding levels |
|---|---|---|---|
| 1. Animal Industries | 37.4 | 37.4 | 0 |
| 2. Dairy Industries | 12.7 | 15.7 | +24 |
| 3. Forage | 21.2 | 22.9 | +8 |
| 4. Horticultural, Arable & other Food and Beverage Industries | 51.9 | 49.1 | -5 |
| 5. Forestry & Forest Product Industries | 22.8 | 26.0 | +14 |
| 6. Fisheries & Aquaculture Industries | 6.6 | 9.7 | +47 |
| 7. Manufacturing Industries & Industrial Technologies | 27.8 | 34.1 | +23 |
| 8. Tourism, Commercial & other Services | 0.5 | 3.7 | +640 |
| 9. Information, Communications Networks & Services | 3.3 | 6.4 | +94 |
| 10. Construction | 3.7 | 5.1 | +38 |
| 11. Energy | 5.0 | 7.6 | +52 |
| 12. Transport & Distribution Systems | 1.3 | 2.8 | +115 |
| 13. Society & Culture | 4.2 | 10.0 | +138 |
| 14. Earth Resources & Processes | 14.5 | 23.0 | +59 |
| 15. Land & Fresh Water Eco-systems | 30.8 | 41.8 | +36 |
| 16. Marine Environments, Climate & Atmosphere | 20.5 | 31.8 | +55 |
| 17. Antarctic Research | 1.9 | 2.9 | +53 |
| TOTAL | $266M | $330M | +24 |

## CHAPTER ONE: GOALS AND SUMMARY OF "SCIENCE & TECHNOLOGY: THE WAY FORWARD 1996 - 2001"

In December 1994, the Government released the Strategic Statement for the Public Good Science Fund entitled "Science and Technology: The Way Forward". This document has set the strategic context for the work of the current panel.

The contents of the strategic statement were drawn in large part from the report produced by the Strategic Consultative Group on Research (SCGR) established by the Government to provide advice on broad strategic directions for the nation's investment through the PGSF.

The statement has a number of broad objectives: an analysis of future trends and research responses over the next 20 year period; delineation of the role and boundaries of the PGSF; goals for the PGSF; and the description of a mechanism for translating the goals and other key factors into actual science priorities.

In considering New Zealand's investment in science and technology over the next two decades, the strategic document acknowledges that New Zealand is a small island nation in the Southern Pacific - a nation that has at its disposal limited resources with which to make its way in an increasingly competitive global marketplace. Science and technology investment is seen as a critically important factor in improving New Zealand's competitiveness and the quality of life of all New Zealanders.

An important aspect of the PGSF is its role and purpose within the wider portfolio of public investment in science and its relationship to private sector investment in research and development. The strategic statement clearly delineates the boundaries between the PGSF and other funding sources. However it also promotes the principle of partnership between funding sources, while clarifying the goals and accountability of funding agencies. Key boundaries are with: public sector operational research; private sector research and development; the Technology for Business Growth (TBG) scheme; the Marsden Fund; and research funded by the Health Research Council.

The Strategic Statement briefly outlines methodologies for assessing the relative importance of the stated economic, environmental and social goals and for converting these weightings into actual output allocations. The Statement comments only in broad terms however as the view is that the Science Priorities Review Panel should take the lead role in further developing and refining the use of methodologies for guiding decisions on output allocations. Importantly, the Strategic Statement sets out the six key factors to be considered by the SPiR in developing recommendations on output funding levels.

The goals set out in the Government's Strategic Statement are reproduced in Table Two.

## Table Two: Goals from the Government's Strategic Statement

### *Science Goals*

- Develop and maintain science capabilities, including skills and knowledge needed to ensure that the priorities set for the PGSF can continue to be achieved in the long term.
- Maintain and strengthen international scientific and technological networking and collaboration, to ensure an adequate knowledge of, and access to, external research knowledge and skills, databases and technologies.

### *Economic Goals*

- Maximise the contribution of research, science and technology to enhancing the quality of life in New Zealand.
- Enhance international competitiveness through research on the generic technologies throughout the value chain from production of raw material to finished product in the market, including approaches to management and innovation, leading to new and differentiated products and services.
- Ensure service, production and processing industries (including biological, extractive, manufacturing and tourism) are economically, environmentally and socially sustainable.
- Achieve a balance, related to market potential, between research into new and differentiated products and services and research into improved efficiency of producing existing products and services.
- Improve competitiveness through increased knowledge and understanding of New Zealand's competitive advantages and disadvantages.

### *Environmental Goals*

- Enhance protection of the environment through action based on an improved understanding of biodiversity, biological and physical systems and the impacts of human activities.
- Ensure sustainable resource management (protection and use) through an adequate knowledge of natural systems, including ecosystems and their sustainable limits.
- Increase understanding of natural physical and biological hazards.
- Improve knowledge of technologies for sustainable resource use to ensure waste minimisation, cleaner production and efficient energy use.

### *Social Goals*

- Improve understanding of key issues affecting acquisition of skills and knowledge necessary for full engagement of individuals in the economy and society.
- Improve knowledge of the social and cultural dimensions and trends of a competitive economy.
- Support Maori development aspirations.
- Integrate social research, in particular research relevant to changes in the economy, resource use, the environment, human health and wellbeing and uptake of research, science and technology into the broader PGSF research portfolio to support equity of opportunity and social cohesion.

## CHAPTER TWO: SUMMARY OF PROCESS USED

### Background

In mid-1994, the Government initiated a process to review its five-year priorities for investment in research, science and technology through the Public Good Science Fund (PGSF). The overall process was to occupy about one year, ending with the issue of a priority statement to the Foundation for Research, Science and Technology (FRST) in mid-1995. The process was planned to consist of three principal phases:

- a strategic phase to define broad strategic goals and directions for investment, and thereby establish an overall strategic context for priority-setting; followed by
- a prioritising phase, to establish the optimal pattern of distribution of the PGSF to support the Government's stated goals and directions; and
- a research strategy phase, to determine for each output the best funding profiles for the five-year life of the priority statement and the details of how the science within each output should be managed.

The first phase was initiated with the appointment of the Strategic Consultative Group on Research (SCGR) in May 1994. The SCGR consulted with key stakeholders and produced a final report, "For the Public Good" in October 1994. This was drawn on by the Government as the basis for its Strategic Statement, "Science and Technology: The Way Forward 1996-2001" in December 1994.

### Science Priorities Review Panel

The Science Priorities Review Panel (known as SPiR) was appointed in December 1994 to oversee the second principal phase of the overall process. The SPiR has been charged with developing advice on the distribution of the PGSF across 17 outputs, defining Key Science Areas (KSAs) and giving other non-quantitative guidelines for investment. The methodology used to guide decisions on output funding levels is summarised in Chapter Five and described in full in Annex Three. The overall process adopted by the SPiR is summarised in Fig 1 and explained below. A fuller explanation is contained in Annex One.

### Consultation process

Prior to Christmas 1994, a wide range of key stakeholders was asked to provide information to the SPiR regarding their views of the key issues relevant to achieving the Government's strategic goals and directions. In parallel with the consultation with key stakeholders, and for each output, the SPiR appointed one convenor and one sub-convenor to reflect both science user and provider perspectives in drawing together technical information to assist its deliberations.

The SPiR spent some time in considering an appropriate quantitative methodology to assist in its overall decision-making process. In so doing, the panel built on the work of both the STEP and SCGR panels, and reviewed material on methodologies from a number of other

sources, including other countries. The quantitative methodology finally chosen by the SPiR was one which aimed at maximising the benefits obtained from the investment portfolio. It assessed each of the key factors in the Strategic Statement and aggregated the impact of these in a systematic way. As required by the Terms of Reference, the chosen methodologies (not only the quantitative methodology) was reported to the Minister of Research, Science and Technology and subsequently endorsed.

Convenors and sub-convenors were asked to address the six key factors. Specific views on elements of these key factors were also sought from a wide range of experts who were consulted through a Delphi survey.

Submissions on Key Science Areas were reviewed by an expert working group, appointed in consultation with The Royal Society. The expert group recommended a list of KSAs which were developed further by the SPiR and are included in this document for comment.

In parallel with this consultation, a complementary and parallel process has been conducted for consulting with Maori. At various points the findings of this parallel process have been presented to the SPiR for incorporation in the panel's deliberations.

Finally, in support of the consultation process, substantial information has been gathered or prepared and analysed specifically for the panel's consideration.

**Decision-making**

The SPiR received almost 200 submissions and substantial amounts of other information. To assist in synthesising and analysing information within the timeframe available, the panel contracted decision support technology from Victoria University in Wellington and Industrial Research Limited for spreadsheeting the quantitative methodology.

**Future process**

The SPiR will now hold a series of public meetings at locations around the country to discuss the current document. A number of hui will also be held as part of the parallel Maori process. The SPiR is allowing a period of six weeks for written submissions to be made on the paper and, where necessary, will seek to meet with sector representatives to elicit further information or clarify points raised in submissions. Following this, the panel will prepare a final report to the Government for its consideration.

The Government will complete the prioritising phase with the release of its priority statement. How these priorities will be implemented will then be determined by the research strategy process to be carried out by the Foundation. In fact, the preliminary information gathering stages of research strategy development will already have been carried out in parallel with the final stages of priority setting. The final act of the overall process will be the approval and release of research strategies in around August 1995.

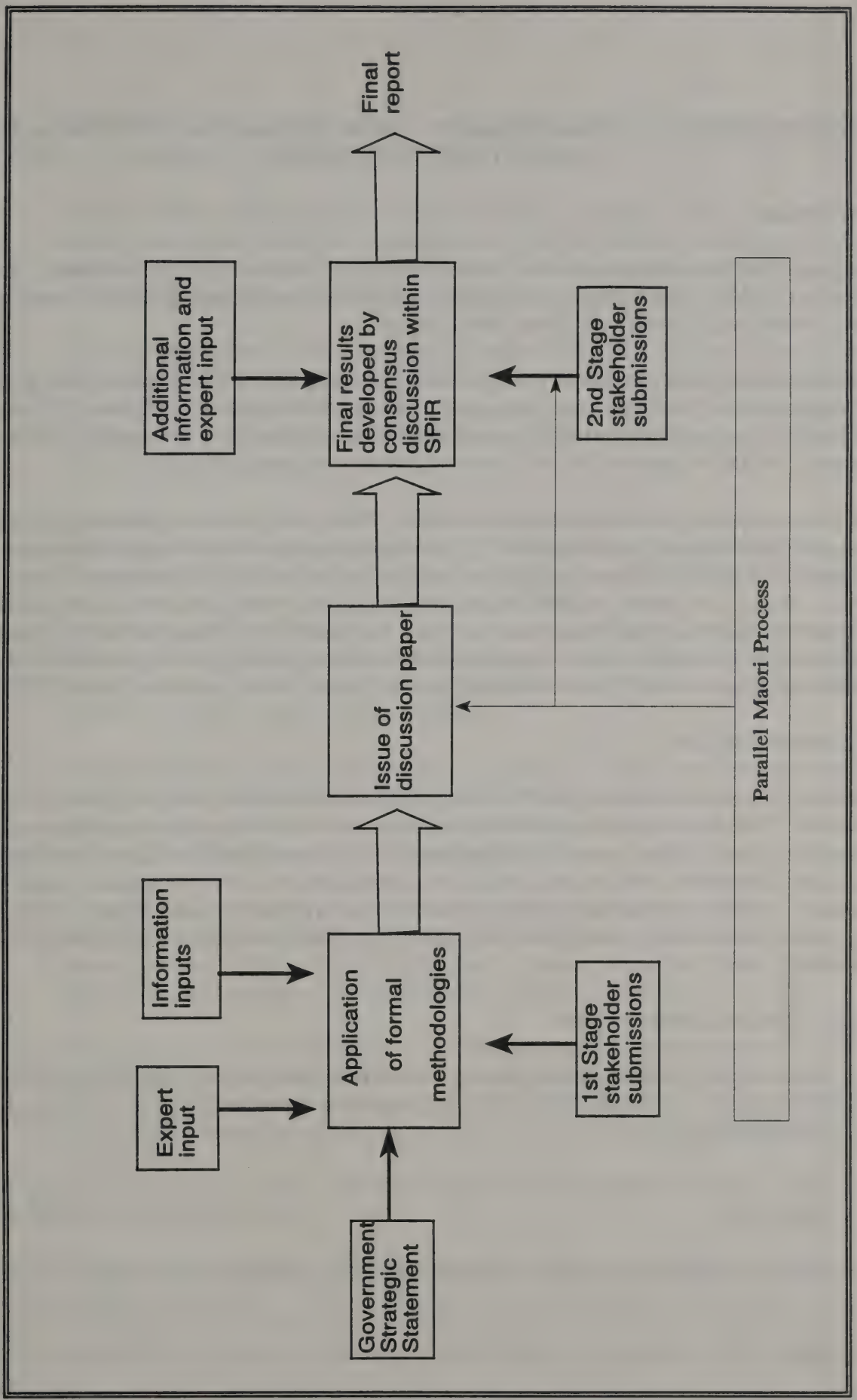


**Fig 1: Overall SPiR process**

## CHAPTER THREE: RESULTS OF THE PARALLEL PROCESS OF CONSULTING WITH MAORI

### Introduction

Maori have the same interests as other New Zealanders in the development of a healthy and prosperous society. There is also a more explicit Maori interest in preserving and fostering Maori culture and in promoting Maori development.

These interests are reflected in the Strategic Statement issued by the Government. The goals in the statement include research support for Maori development aspirations. It also identifies the need to understand key issues affecting the acquisition of skills and knowledge necessary for full engagement of individuals in the economy and society.

Maori are not well represented in the science sector. The process for setting science priorities has therefore included a "parallel process" to investigate the aspirations of Maori with respect to research. This parallel process aims to define a suitable consultation process, build a network, identify key issues, validate the information gained, widen the scope of discussion, and provide a forum for discussions on priorities and other issues affecting Maori participation in the science system. In the section below the parallel process is described and an indication given of how the results might be incorporated in the priorities for the PGSF.

### The process until now

Meetings were held in August 1994 at Whangarei, Auckland, Ngaruawahia, Rotorua, the Manawatu, Wellington and Lincoln. Maori who had some knowledge of science were asked to provide a view on what issues were significant. A constant dialogue with various Maori groups and individuals was sought through the remainder of 1994. A second round of meetings, in which approximately 60 people took part, were held in February 1995 at Christchurch, Auckland, Taranaki, Hastings and Otaki. Some written submissions were also received.

The key questions addressed were:

- *In developing the capability of the research sector through the Public Good Science Fund, to what extent should the science effort reflect Maori aspirations, and what are those aspirations?*

- *How can the capability and interface of Maori with "Mainstream" science be improved?*

- *How and where does Matauranga Maori interface with mainstream science?*

### Key themes

A number of key themes have surfaced through the consultation process, and have been tested and validated as consultation has proceeded. Those themes so far identified by Maori,

and included in this document for further consideration through the parallel consultation process, are as follows:

- To date, Maori interest in the PGSF has tended to focus on the social sciences, although not to the exclusion of other areas. This is a reflection of several things, including the fundamental development needs of Maori together with the placement of traditional and cultural knowledge in the social science output.

- Of particular concern is the retention of the traditional knowledge of New Zealand flora and fauna and other natural resources, traditional living skills and the philosophical structures which support the knowledge paradigm. These, together with their potential for research and development, are seen to be *taonga* under Article II of the Treaty of Waitangi

- Maintenance of the quality of the environment is of particular importance to Maori. The concept of *kaitiakitanga* (guardianship) is fundamental. Research which supports the sustainability of the biophysical environment is therefore in the Maori interest.

- The development of Maori assets is of fundamental importance. This development intersects with almost all output classes, although the consultation process has often identified Forestry & Forest Product Industries and Fisheries and Aquaculture Industries as being of particular importance.

- Matauranga Maori encompasses a holistic world view which does not easily match the systems of classification used by the PGSF and in mainstream science. Issues relating to the interface between science knowledge obtained within a "western" paradigm, and that embedded in Matauranga Maori, need to be better investigated.

- A significant issue facing Maori relates to equitable access to the science system as embodied in Article III of the Treaty of Waitangi. Applications for funding of research related to Maori interests often do not meet the normal science criteria and may not succeed despite having significant merit in a wider sense.

- Maori groups perceive that there is a significant under-representation of Maori in Crown-owned research organisations, in part because few Maori have relevant post-graduate qualifications in science. This is paralleled with a lack of criteria for evaluating the expertise of alternative science providers and research bids received from them.

**The implications for priorities**

The above themes suggested through the consultation process are recognised by the panel as warranting further attention. However only some aspirations of Maori can be realised through the statement of priorities for the PGSF. Aspirations which do not accord with the panel's mandate but on which it would like to make positive suggestions are as follows:

- There is only a partial overlap between science able to be funded through the PGSF and that body of knowledge known as Matauranga Maori. If Maori have a concern

about traditional knowledge it is accordingly important that the concern is addressed by routes other than (or in addition to) the PGSF. The panel would support wider initiatives to address this issue.

- Access to the science system is a persistent and legitimate concern. However it is a concern that cannot be pressed through the priority mechanism past a certain point. An over-riding characteristic of the PGSF system is that all bids should be treated equally and that proposals should be examined strictly on the grounds of relevance and merit. The panel suggests that the Foundation continue and strengthen its efforts to ensure that no bidders are unfairly disadvantaged through lack of familiarity with procedures or cultural/educational background.

  However the panel acknowledges that this step in itself will not solve the problem. Neither are solutions confined to the PGSF. The interim conclusion of the panel is therefore that the Government should consider the issue of Maori access to all aspects of the science system through policies which focus on identifying and addressing the underlying problems.

So far as the PGSF is concerned the panel has reached the following interim conclusions in regard to issues raised by Maori:

- The "Society and Culture" Output (Output 13) is already the focus for research on general aspects of Maori society and culture, and the interaction between mainstream science and Matauranga Maori. This focus will be enhanced by the panel's conclusion that under all funding scenarios, funding for this output should increase.

- Furthermore the panel is of the view that a proportion of Output 13 should continue to be set aside by the Foundation for Research, Science and Technology for dealing with Maori issues and that this proportion should at least be maintained. The question of the exact proportion and the description of what research should be encompassed in the Maori component, should be addressed in the Output Research Strategy developed by the Foundation.

- The conduct of research which will enhance Maori development should be encouraged in all outputs i.e. across the output framework. This particularly applies to research which underpins the sustainable development of natural resources in which Maori have a significant ownership stake e.g. land, forestry and fisheries. To emphasise this point the panel believes that Maori development should be specified as a <u>cross output theme</u>.

  [Cross output themes are discussed further in Chapter Ten. In summary the panel's view is that the Foundation for Research, Science and Technology should be required to develop strategies for specified cross output themes, to complement the research strategies developed for the individual outputs.]

- Finally, retention of traditional Maori knowledge (which could assist research into the New Zealand environment) is proposed as a Key Science Area. Research into maintenance and utilisation of New Zealand's unique flora and fauna, whilst beset

with intellectual property complications, is also an area of considerable interest to Maori and has also been proposed as a KSA (see Chapter Nine and Annex Five).

**The process from here**

In addition to calling for written submissions, three hui are being organised, in various locations and in early April, to provide opportunities to discuss this discussion document with members of the panel. Information about these hui has been distributed separately to the network that has been built up over the last year. Further information can be obtained by contacting Dr Terry Lomax, c/- the Ministry of Research, Science and Technology in Wellington.

## CHAPTER FOUR: FUNDING SCENARIOS

### Introduction

The panel is required to recommend proportionate funding levels in each of the 17 outputs in the output framework, for the 2000/01 financial year. The recommendations will clearly be influenced by the amount of funding available, and especially by the level of funding at the end of the five year period (i.e. 2000/01) compared with the level at the beginning (i.e. 1996/97) because of transitional factors. Different funding scenarios could well lead to different proportionate allocations.

Government now establishes expenditure baselines on a rolling three year basis, although each annual budget contains detail only for the immediate year ahead.

The panel's Terms of Reference contains the following statement about funding scenarios:

***"Background Assumptions on Funding Levels***

*The baseline level of funding for the PGSF is $ 273M in 1996/97, excluding Non Specific Output Funding (NSOF).*

*No specific commitments have been made to levels of funding beyond 1996/97. However funding will not be less than the 1996/97 level of funding. Accordingly the panel is to develop its recommendations on the basis of a range of scenarios. The number of scenarios will be at the discretion of the panel but should include:*

*a* *At the lower bound, continuation of funding at the 1996/97 level.*

*b* *At the upper bound, a smoothly increasing profile of funding which is consistent with the Government's commitment to achieving <u>total</u> science funding of 0.8% of GDP by the year 2010."*

The 1996/97 level for the PGSF, stated in the Terms of Reference as $273M, has since been reduced to $268M by technical adjustments (e.g. a transfer of some funding to the Marsden Fund). In 1994/95 the PGSF is 50% of the total public investment in science.

Having considered a number of different funding scenarios the panel has decided to base this discussion on three scenarios:

- a *LOW* funding scenario of **$290M p.a.** in 2000-01;
- a *HIGH* funding scenario of **$370M p.a.** in 2000-01; and
- an *INTERMEDIATE* funding scenario of **$330M p.a.** in 2000-01.

The high and low scenarios were those used throughout most of the panel's deliberations but the emphasis in the interim outcome is on the intermediate scenario.

Thus the panel has included figures for all three scenarios but has addressed its comments to the intermediate scenario. The panel also intends to consult principally on the basis of the intermediate figure but to develop guidelines for inclusion in its final report, which will enable distribution of the PGSF to be calculated for whatever funding trajectory the Government eventually decides to adopt. This approach will provide a means of unambiguously modifying the 1995 priority statement as funding firms up from year to year.

## CHAPTER FIVE: SUMMARY OF METHODOLOGIES

A range of methodologies was adopted by the panel. They included selected use of Delphi surveys, application of a quantitative model and the direct scoring of funding levels by the panel. The approaches used are summarised as follows:

### Delphi

A restricted Delphi survey was conducted for the panel by Victoria University staff. Sixty selected respondents were asked to score the key factors to be addressed through the methodology see table, and the mean, mode, and standard deviations of the Delphi results were given to the panel. Delphi respondents were chosen to give a range of expertise and their interests covered all of the 17 outputs in the framework.

### Quantitative methodology

The Government's Strategic Statement presented the panel with a framework of 17 outputs, across which total funding was to be allocated, and six factors which were to be considered in establishing priorities between the outputs. These factors are as follows:

| | |
|---|---|
| 1 | Strategic Importance<br>(the potential contribution of the output to achieving the Government's economic, environmental and social goals) |
| 2 | Potential of Science in each Output<br>(The likelihood that research will achieve results) |
| 3 | Potential of Users to Capture Benefits<br>(The extent to which users of research in the output will capture its benefit, and their timeliness in doing so) |
| 4 | Research Capacity<br>(The quantity and quality of resources available in New Zealand to support current and future research) |
| 5 | Research Intensity<br>(The extent to which the sector is dependent on investing in research for its success) |
| 6 | Appropriateness of PGSF Funding<br>(The extent to which research in the output should be funded from the PGSF compared to other sources) |

The panel decided to "score" each output against each of these factors and arrive at an overall weighting for each output by aggregating the scores through a set formula. The formula employed factors 1 and 6 as primary multipliers and the sum of weighted factors 2-5 as a secondary multiplier (although factor four was actually weighted at zero and had no influence at this stage - it was used as a transition factor later on). The weight for each output was then multiplied by the available funding (i.e. $290m or $370m under the two chosen scenarios) to produce the first trial results. The formula-based result was sensitivity-

tested by altering the formula itself, and by varying the weights of various factors. These calculations provided a sense of the directions in which shifts should occur.

Although the methodology includes provision for the application of transitional factors (over and above the factors one to six listed above) the panel decided to consider transitional factors separately. Details of the quantitative methodology are set out in Annex Three and the results of applying the methodologies are in Annex Four.

**Direct assessment**

Initially, in parallel with the quantitative methodology, a separate exercise was carried out in which funding was directly assigned to outputs. This was done according to the panel's combined judgement, based on individual members' knowledge and the information provided during the consultation process.

This initial combined judgement was compared with the formula-based result and further iterations of scoring carried out as the panel closed in on an answer which was acceptable to the panel.

The rescoring and repeated examinations of the result were made possible by the use of the Victoria University Decision Support Centre. The panel debated their scores between each scoring round, paying particular attention to the views of "outliers" in the group.

In reaching its conclusions the panel used the quantitative model results as an input only, not as an arbiter of what was desirable. In particular:

- the panel was as much influenced by the discussion and thinking lying behind the assessment of the key factors as by the formula result of aggregating the factor scores;

- the panel was influenced by transitional factors, including the achievable speed of change, the need to preserve important science capability, and the need to give positive signals to sectors investing significantly in research on their own account; and

- finally and most significantly, the panel had regard to the whole range of inputs available to it including stakeholder submissions, output reports by the sector convenors, special reports commissioned, and the panels' own knowledge and understanding of science in each of the outputs.

The final distribution produced by the panel is shown in Chapter Seven.

**Key Science Areas**

The panel also identified a number of potential Key Science Areas (KSAs) according to the process described in Chapter Nine. Final selection of KSAs, and their more detailed description, will be determined through the consultation process which follows the release of this document.

**Output framework**

The 17 Output Framework set out in the Government's Strategic Statement has been accepted as the framework for expressing future funding targets for the PGSF. The analysis contained in the discussion paper (particularly that using the quantitative methodology) has been done on this basis.

However, the 17 Output Framework does create analytical difficulties because in some cases it aggregates quite different sectors and areas of research. Comparisons of research between and within outputs are therefore made difficult. If it had more time, the panel would have given serious consideration to disaggregating some outputs for the purposes of analysis, and proposes that this step be considered in future priority-setting exercises. Among those outputs which might be better analysed in disaggregated form are the following:

Output 4 Disaggregated to separately represent live products (crops, fruit etc) and processed products.

Output 7 Disaggregated to separately represent major mineral based or heavy industries (iron and steel, aluminium, cement etc) and other manufacturing.

Output 8 Disaggregated to separately represent services (banking, commercial services, government services etc) and tourism.

Other outputs could possibly be usefully disaggregated for analytical purposes and the panel would be interested in views on that subject.

## CHAPTER SIX: BACKGROUND TO DECISIONS ON OUTPUT FUNDING LEVELS

### Linkage to the STEP process

Following the STEP process, the Government issued "Investing in Science for Our Future", a paper presenting the Government's Statement of Science Priorities for the PGSF. That paper outlined a number of strategic directions with respect to funding, partnership and concentration of resources. Notwithstanding the changes that have occurred since 1992, the SPiR has found no reason for those basic strategic directions to be changed, and has incorporated them in its thinking and, where appropriate, in the guidelines contained in this document.

In terms of its actual recommendations for output funding levels however, the SPiR has recommended a balancing in the overall portfolio which is different from that recommended by the STEP. The background to this shift is explained below.

### Strategic context

The context for the SPiR deliberations was established by the Government's Strategic Statement, which was in turn derived from the work of the Strategic Consultative Group on Research. The panel was in particular influenced by the broad themes drawn in the Strategic Statement and by the goals set out. The three sets of goals (economic, environmental and social) were seen to reflect the changes that had occurred in the national and global situation since the last priority-setting process which took place in 1992. The science goals contained in the Strategic Statement were considered to overarch the whole PGSF, and were not in themselves used in determining relativities between outputs.

The Science and Technology Expert Panel (STEP) which oversaw the last process operated within a very different set of circumstances than that faced by the SPiR. STEP was faced with a static PGSF and the need to rebalance expenditure within that constraint. The Government is now increasing its expenditure in science, especially through the PGSF, and this has created the more positive context for allocating funding.

In 1992 there was a strong focus on economic development, which reflected the relative stagnation of the economy and a determination at all levels to make growth a top priority. In 1995 the commitment to growth remains and is reflected in the deliberations of SPiR. However that commitment is now complemented by a concern for a wider range of issues with an environmental and social content. These issues are spelt out in the Government's Strategic Statement and will have a strong influence on this country's science agenda. They include the ramifications of the GATT, including non-tariff barriers to global trade, increased globalisation and the growing importance of sustainable development, international conventions and demographic and technological change.

### Relative weightings of PGSF goals

The close inter-relatedness of the Government's strategic goals is recognised. Nevertheless, the panel found it desirable to establish relative weightings for the three main goal sets (and

it was required to do by the methodology that was adopted). These weightings were derived in a number of ways, including the Delphi survey, and proved to be remarkably robust. There was a surprisingly strong consensus in the panel and in the Delphi group in support of the split shown in the table below:

**Table Three: Relative weightings of strategic goals from the Government's Strategic Statement**

| Goal sets | Relative importance (%) |
|---|---|
| Economic | 50 |
| Environmental | 30 |
| Social | 20 |

In simple terms, this table means that in determining strategic importance for the PGSF, economic goals are of approximately equal importance to the environmental and social goals combined.

In 1992, the starting point for the STEP was a set of Government-approved desired "outcomes" and it is clear now that these were much more focused on economic growth than are the present set of Strategic Goals. This shift of strategic emphasis has had a strong bearing on the proposals set out in this discussion document.

However the Strategic Goals do not map directly onto the output framework, nor into funding distributions. In developing funding levels, the SPiR took account of the contribution of the "economic" outputs to achieving environmental and social goals, and of the environmental and social outputs to economic goals.

**The role of the PGSF**

The other major change since 1992 has been greater recognition of the relative appropriateness of PGSF funding as a key factor in consideration of the "public good" in different areas of research. All other things being equal, considerations of "public good" tend to favour research with a strong environmental or social content. The Strategic Statement's description of the role of the PGSF has also clarified the relationship of the PGSF to other funders across the various sectors. An important aspect of the PGSF is its role and purpose in the context of wider public investment in the broad science envelope and its relationship to private sector investment in research and development. The strategic statement clearly delineates the boundaries between the PGSF and other funding sources, while encouraging the principle of partnership between funding sources, and clarifying the goals and accountability of funding agencies.

## CHAPTER SEVEN: OUTPUT FUNDING LEVELS: DESCRIPTION & COMMENTARY

### Output funding levels

Tables four and five show the panel's interim conclusions on output funding levels.

**Table Four: Output Funding Levels for 2000 - 2001: $290M, $330M & $370M Scenarios; Nominal Figures ($M)**

| Output Titles | | 1995-96 Funding (estimated) | Proposed Funding ($290M) | Proposed Funding ($330M) | Proposed Funding ($370M) |
|---|---|---|---|---|---|
| 1. | Animal Industries | 37.4 | 34.6 | **37.4** | 40.1 |
| 2. | Dairy Industries | 12.7 | 13.3 | **15.7** | 18.1 |
| 3. | Forage | 21.2 | 20.8 | **22.9** | 25.0 |
| 4. | Horticultural, Arable & other Food and Beverage Industries | 51.9 | 45.8 | **49.1** | 52.5 |
| 5. | Forestry & Forest Product Industries | 22.8 | 22.8 | **26.0** | 29.1 |
| 6. | Fisheries & Aquaculture Industries | 6.6 | 7.6 | **9.7** | 11.8 |
| 7. | Manufacturing Industries & Industrial Technologies | 27.8 | 29.7 | **34.1** | 38.5 |
| 8. | Tourism, Commercial & other Services | 0.5 | 2.7 | **3.7** | 4.7 |
| 9. | Information, Communications Networks & Services | 3.3 | 5.0 | **6.4** | 7.8 |
| 10. | Construction | 3.7 | 4.2 | **5.1** | 6.0 |
| 11. | Energy | 5.0 | 6.3 | **7.6** | 9.0 |
| 12. | Transport & Distribution Systems | 1.3 | 2.3 | **2.8** | 3.2 |
| 13. | Society & Culture | 4.2 | 8.2 | **10.0** | 11.8 |
| 14. | Earth Resources & Processes | 14.5 | 20.1 | **23.0** | 25.9 |
| 15. | Land & Fresh Water Eco-systems | 30.8 | 37.5 | **41.8** | 46.1 |
| 16. | Marine Environments, Climate & Atmosphere | 20.5 | 26.6 | **31.8** | 36.9 |
| 17. | Antarctic Research | 1.9 | 2.4 | **2.9** | 3.5 |

## Table Five: Output Funding Levels for 2000 - 2001: Percentage Changes from Current Levels

| Output Titles | | 1995-96 Funding (estimated) | Proposed % change 2000-01 ($290M) | Proposed % change 2000-01 ($330M) | Proposed % change 2000-01 ($370M) |
|---|---|---|---|---|---|
| 1. | Animal Industries | 37.4 | -7.5 | 0 | +7.2 |
| 2. | Dairy Industries | 12.7 | +4.7 | +24 | +42.5 |
| 3. | Forage | 21.2 | -1.9 | +8 | +17.9 |
| 4. | Horticultural, Arable & other Food and Beverage Industries | 51.9 | -11.7 | -5 | +1.2 |
| 5. | Forestry & Forest Product Industries | 22.8 | 0 | +14 | +27.6 |
| 6. | Fisheries & Aquaculture Industries | 6.6 | +15.1 | +47 | +78.8 |
| 7. | Manufacturing Industries & Industrial Technologies | 27.8 | +6.8 | +23 | +38.5 |
| 8. | Tourism, Commercial & other Services | 0.5 | +440 | +640 | +840 |
| 9. | Information, Communications Networks & Services | 3.3 | +51.5 | +94 | +136.4 |
| 10. | Construction | 3.7 | +13.5 | +38 | +62.2 |
| 11. | Energy | 5.0 | +26.0 | +52 | +80.0 |
| 12. | Transport & Distribution Systems | 1.3 | +77.0 | +115 | +146.1 |
| 13. | Society & Culture | 4.2 | +95.2 | +138 | +180.9 |
| 14. | Earth Resources & Processes | 14.5 | +38.6 | +59 | +78.6 |
| 15. | Land & Fresh Water Eco-systems | 30.8 | +21.8 | +36 | +49.7 |
| 16. | Marine Environments, Climate & Atmosphere | 20.5 | +29.8 | +55 | +80.0 |
| 17. | Antarctic Research | 1.9 | +26.3 | +53 | +84.2 |

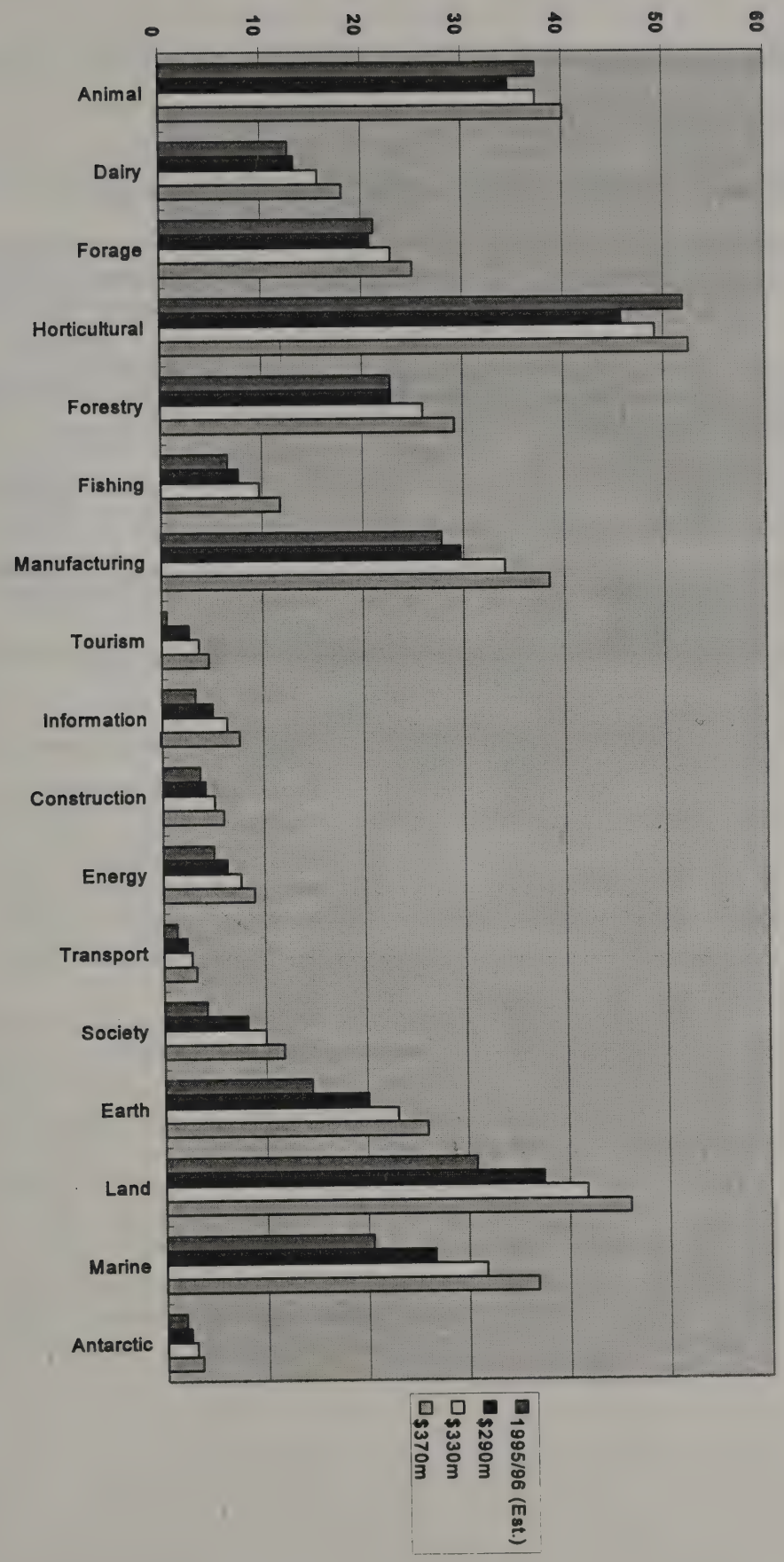


**Fig 2: Funding shifts for $290M, $330M and $370M scenarios compared with current output funding levels**

**Aggregate funding balance**

The broad shifts are shown in the table below.

**Table Six: Change in aggregate funding balance for $330M Scenario**

| Output Nos | Aggregate names | Approximate percentage of PGSF funding 1995/96 | Projected percentage of PGSF funding in 2000-01 ($330M scenario) |
|---|---|---|---|
| **1-12** | Primary Industries & Manufacturing | 73 | 67 |
| **13** | Society | 2 | 3 |
| **14-17** | Biophysical Environment | 25 | 30 |

## CHAPTER EIGHT: COMMENTARY ON INDIVIDUAL OUTPUT FUNDING RESULTS

The following section summarises the SPiR's analysis of each output. The commentaries apply to the intermediate ($330M) funding scenario.

### *Output One: Animal Industries*

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 37.4 | 34.6 | **37.4** | 40.1 | **0%** |

Although this output scored well on a number of factors, the quantitative methodology indicated that a relative decline in funding should occur. This outcome was consistent across a range of different assumptions. This is not an adverse reflection on the importance of this area of science, but rather reflects the continuation of historically high levels of funding despite, major shifts in the balance of New Zealand's economic activity over the past twenty years and industry projections for declining production.

Nevertheless the panel's view was that funding should be unchanged. This conclusion is an amalgam of a number of considerations. One is that this output is the focus of several Key Science Areas. For example, molecular technologies offer significant opportunities for increasing competitive advantage through efficiency gains and product differentiation. The panel also sees considerable scope for more emphasis on addressing post-GATT issues and sustainability through the integration of production and processing research with environmental and social research. The environmental impacts of animal industries on land and water are of particular importance, as is animal welfare. This output also contains much of the background research on possum control and bovine Tb, which are the subjects of a National Science Strategy. These issues suggest that research strategy development will be particularly important for this output.

*Output Two: Dairy Industries*

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 12.7 | 13.3 | **15.7** | 18.1 | **+23%** |

Dairy production and processing is viewed as a strong growth industry with well established international market niches in a wide range of value added dairy products. The sector is coordinated by the New Zealand Dairy Board. It is akin to a large vertically integrated company with ownership interests in onshore and offshore processing, research and development, and global marketing, and with further significant links to farm production research.

The New Zealand dairy industry is innovative and has an established international reputation for efficient farm production and high quality milk products, reflecting a large investment in, and commitment to, research and development.

From a public good research viewpoint, the integration and technological orientation of the industry equates to an excellent capability to capture the benefits of research, as well as high research potential. The panel has correspondingly scored the output highly on these factors. The research intensive nature of the industry has resulted in a high weighting to this factor.

The appropriateness of PGSF investment in the dairy output has been given less weighting than for most other outputs. This reflects the reduced scope for projects to meet the qualifying criteria for public good funding as a result of the industry's high level of integration. Despite this, the modelling work undertaken indicates that funding in this output is low relative to other primary production and processing outputs. The panel's conclusion is thus that the funding level for this output should be increased to more adequately reflect other factors, especially the sector's strategic importance in terms of its relative contribution to GDP.

***Output Three:*** ***Forage***

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 21.2 | 20.8 | **22.9** | 25.0 | **+8%** |

The existence of a separate forage output within the PGSF is partly an acknowledgement of the central role played by pasture in the New Zealand economy, and of the fact that a substantial proportion of the New Zealand land surface is covered in grassland.

Pasture generates income indirectly through New Zealand's pastoral industries. To help establish a weighting for the strategic importance of the forage output, the panel has made an estimate of the GDP component represented by forage. The GDP components of the animal and dairy outputs have been adjusted accordingly.

This output scores highly on research potential and research intensity. This is in acknowledgement of the potential impact of new biotechnology, and the importance of the environmental aspects of this output. The output also scores relatively highly on ability to capture benefits and appropriateness of PGSF funding.

However the panel's conclusion is that only a slight increase in funding is justified, again reflecting the high historical levels of funding for research in this output.

*Output Four:* ***Horticultural, Arable and other Food and Beverage Industries***

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 51.9 | 45.8 | **49.1** | 52.5 | **-5%** |

This output currently captures almost 20% of the PGSF. The panel considers this to be disproportionately high relative to its strategic importance, particularly as indicated by its contribution to GDP. This situation appears to be partly a reflection of the view held in the past that New Zealand would develop new, rapidly growing industries in this sector to eventually match the size of the kiwifruit or pipfruit industries. The degree of sector development that has actually occurred does not support this view. The panel's conclusion it thus that funding should decline slightly to give a more justifiable strategic balance within the PGSF portfolio.

The panel does not however wish to see any funding reductions applied uniformly within the output, and in this case found the output framework to be a constraint to effective priority-setting. This output contains many component parts which should ideally be considered on their own merits, while not jeopardising the vertical integration sought by the original output design. In particular, the panel considers that horticulture has probably received a disproportionate share of funding in comparison to industries of similar sizes in other outputs.

The panel is also strongly of the view that the efforts of the arable sector in establishing industry levies and a research foundation, partly as a result of the 1992 STEP process, should not be penalised. In some other sectors in this output, the panel considered the proportion of industry funding to be too low, particularly when the size of the PGSF contribution to funding generic research was taken into account.

***Output Five:*** ***Forestry and Forest Products Industries***

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 22.8 | 22.8 | **26.0** | 29.2 | **+14%** |

An historically close relationship between the predominant science provider and industry has resulted in the panel scoring this output highly with respect to the ability to capture benefits. Research intensity and research potential have also been rated relatively highly, reflecting the continued importance of research into new genetic variations and species, growth efficiency, in improving product quality and in attaining competitive advantage in international solid wood, reconstituted board, and pulp and paper markets. This output also has major implications in terms of land use and general environmental impacts and, along with fisheries, was one of the "economic" outputs identified as being of particular importance to Maori.

Because there is a high degree of market concentration in some sector activities, appropriateness of PGSF funding has been scored relatively low in comparison to some other outputs (although not as low as might have been the case had there not been low concentration in areas such as sawmilling). The panel's conclusion is that funding should be increased.

***Output Six:*** ***Fisheries and Aquaculture Industries***

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 6.6 | 7.7 | **9.7** | 11.8 | **+47%** |

This output was rated highly in terms of the growth potential arising both from science and from the potential expansion of New Zealand's already-large economic exclusion zone. However this needs to be moderated by the sector's comparatively modest contribution to GDP. The fishing industry is a key contributor to supporting Maori development aspirations.

Many marine resources are not yet fully utilised, even though stocks of the five main fish species are being harvested at or near their level of long-term yield. Aquaculture in particular is seen as having potential for rapid growth, underpinned by scientific research. The panel has also been influenced by the traditional and recreational component in fishing which is not recognised in GDP statistics

The panel's conclusion is that funding should be increased, partly in recognition of the need for ecosystems research and ensuring sustainability (this output is closely linked to the science in the Marine and Atmosphere Output). The conclusion is however a cautious one, due to some uncertainty about growth projections and because of the very large amount of funding applied to stock assessment and monitoring from non-PGSF sources.

***Output Seven:*** ***Manufacturing Industries and Industrial Technologies***

Funding level

| **Output funding levels in nominal millions of dollars** | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 27.8 | 29.7 | **34.1** | 38.5 | **+23%** |

Overall, the manufacturing industry has recently demonstrated significant growth in its contribution to New Zealand's wealth and welfare. The industry is very diverse however and while the growth of some sectors within it has been remarkable, others have been less impressive. There is much scope for research into efficient, clean and sustainable resource use and for integration with processing research in other outputs, particularly those in the primary production and processing sectors. Much relevant research is carried out overseas and the results imported into New Zealand and adapted here, although an indigenous research capability is also clearly required.

The role of the PGSF in respect of the output is therefore quite complex, and this is a case where the output could usefully be disaggregated for the purposes of analysing and expressing priorities. The focus should be on supporting generic research which underpins innovative and research intensive manufacturing, without risking the displacement of industry funding for applied research with appropriable benefits. On the other hand, there

is evidence to suggest that in some areas within the industry there is a low level of technological awareness and poor structures for facilitating technology uptake. In these latter cases other instruments of Government policy, such as the Technology for Business Growth or Graduates Within Industry schemes, may be more appropriate for creating a technology culture.

The suggested moderate level of increase in funding recognises the strategic importance of the industry, but moderated by its heterogeneity and the panel's assessed appropriateness of PGSF funding in the output.

***Output Eight:*** ***Tourism, Commercial and other Services***

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 0.5 | 2.7 | **3.7** | 4.7 | **+640%** |

The panel experienced difficulty in considering this output, given its diversity and very large size within the economy, and was inclined to split it for the purposes of expressing priorities. Much of the output as it is currently constructed consists of services, such as retailing and banking, where there seems to be little obvious scope for public good research.

The panel notes recent efforts to develop a research strategy within the tourist industry, but remains unconvinced that there are significant opportunities for projects meeting PGSF criteria. However, given the high strategic importance of tourism in terms of its contribution to the economy and its environmental and social significance, the panel considers that current funding levels in the output are too low.

PGSF research is seen as being highly appropriate, given the fragmented and diffuse nature of the industry. A small absolute increase (although large in percentage terms) is suggested, conditional upon the development of sufficient relevant, high-quality bids and the development of a coherent, industry-wide research strategy.

*Output Nine:* ***Information and Communications Networks and Services***

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 3.3 | 5.0 | **6.4** | 7.8 | **+94%** |

The growth of information and communications sector has profound implications for all other sectors and for society as a whole. While the level of private funding of research is high, this is seen by the panel as appropriate, given the highly applied and appropriable nature of much of this activity. This is particularly so in the communications field, where there is a high degree of industry concentration.

There is a particularly high potential for technology application in information and communications, although many developments will take place in other countries and be imported to New Zealand for adaptation to local needs rather than arise from local research. The panel recognises that New Zealand has a record of innovative performance in this area, and that a high level of capability is required to effect this adaptation. The PGSF has a legitimate role to play in funding underpinning research in support of this capability.

The panel's view is that an increase in funding is justified for this output. In part this reflects a rebalancing of the current very low relative level of funding.

*Output Ten:* ***Construction***

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 3.7 | 4.2 | **5.1** | 6.0 | **+38%** |

The construction sector contributes significantly to the nation's GDP. Also about 25 percent of the nation's energy is used in the residential and commercial sectors, where building design can have a significant effect.

In acknowledgment of the importance of the sector to the economy and to the infrastructure of the nation, strategic importance is rated similarly to that for other economically oriented outputs. In terms of other factors however, construction is not scored highly. This reflects a number of considerations with respect to the sector: there are large players in the building materials industry capable of funding the majority of research, which is largely of an applied nature; and a large part of the sector, the building industry, has low research intensity and is technologically mature. The PGSF is seen as mainly appropriate to specific areas of the sector, such as earthquake design, energy management, and generic research in construction.

Overall, the panel's view is that the current level of funding in the output does not reflect its importance relative to other outputs, and that a modest increase is justified in order to achieve a rebalancing.

***Output Eleven: Energy***

Funding level

| **Output funding levels in nominal millions of dollars** | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 5.0 | 6.3 | **7.6** | 9.0 | **+53%** |

Modern life is dependent on adequate, secure and affordable supplies of energy. In the transport sector New Zealand continues to be dependent on traditional hydrocarbons and this emphasises the importance of local exploration and production. In the commercial and residential sectors, New Zealand has enjoyed a reasonable degree of insulation from global energy concerns due to abundant hydro-electricity produced at very low cost. Currently, however, New Zealand is entering a period of sustained growth and energy demand is projected to rise. Concurrent with this trend is an increased awareness that the exploitation of traditional energy resources is associated with significant environmental costs.

There is accordingly a need to ensure that options for supply from renewable energy sources are adequately researched, while acknowledging a need to retain an ability to utilise New Zealand's own natural, non-renewable resources. Energy management and conservation will also be critical areas of research.

From the perspective of public investment in research, the technology for future development must however be seen in the context of the structure of the energy sector. Currently, the sector is dominated by large players with the capacity to fund the majority of the research needed to develop future supply and energy management technologies. There is also a strong international programme in energy research, much of which is adaptable to New Zealand conditions. The energy sector has significant areas of mature technology. Price is a very strong determinant of technologies adopted.

To reflect these considerations, the panel scored the output relatively highly on strategic importance, but less highly on research potential and the ability to capture benefits.

Appropriateness of PGSF funding was given a moderate score with respect to other outputs despite the domination by technologically competent and large companies. As much as anything this reflects a concern that there are structural problems in the sector which if not corrected will distort the scope of privately driven research. For example it is evident that current electricity prices are below long-term marginal cost and this is bound to have an inhibiting impact on both alternative forms of generation and effective management of demand. The overall conclusion thus is that funding of this output should increase.

***Output Twelve:*** ***Transport and Distribution Systems***

Funding level

| **Output funding levels in nominal millions of dollars** | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 1.3 | 2.3 | **2.8** | 3.2 | **+112%** |

Given New Zealand's geographical makeup and its distance from markets, transport and distribution systems make a significant economic contribution. They also have major environmental impacts and social implications.

Some modes, such as air and rail transport, are operated within highly concentrated industry structures where there is little requirement for PGSF funding. Conversely, the road transport industry is fragmented, although the potential exists for funding research from user charges. Furthermore, much transport research can legitimately be classified as operational and within the realm of government agencies with particular responsibility for air, sea or land.

Transport research is in large part undertaken overseas and imported in the form of finished vehicles, but there remains a requirement for research aimed at meeting unique local needs.

In particular, there are benefits to be gained from using information systems and intelligent technology to increase efficiencies and safety and to prevent or ameliorate environmental damage. In recognition of the strategic importance of the sector and of the need for such generic, underpinning research, the panel's view is that there should be an increase in the output funding level.

While this suggested increase is high in percentage terms, it is based on a currently low level in absolute terms. Even so, the panel is concerned to ensure that this increase would be supported by the development of sufficient relevant, high quality bids and the development of a coherent industry-wide research strategy.

***Output Thirteen:*** ***Society and Culture***

Funding level

| **Output funding levels in nominal millions of dollars** | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 4.2 | 8.2 | **10.0** | 11.8 | **+138%** |

Social research has significant potential to support the achievement of all of the goals defined in the government's strategic statement. Given the relative weighting of social goals, the panel considers that the level of PGSF investment in related research has been inadequate, and that there should be an increase in funding. In this respect, the panel is inclined to continue the trend initiated by the 1992 STEP exercise. Like the STEP however, the panel holds the view that the realisation of increased funding should be dependent upon the further development of recent initiatives to develop a coherent strategic focus to public good social science research, and to ensure uptake of results.

The panel is firmly of the view that increases in social science funding should not be concentrated solely in Output 13. Output 13 is concerned with background information, specialist areas of the social sciences and systems. As indicated in the Government's Strategic Statement it is essential that the bulk of science oriented to social goals should be within other outputs.

The panel also notes with concern the apparently low level of research related to social policy by government departments with responsibilities in this area. Increases in PGSF funding for the social sciences should proceed cautiously, in line with the development of a coordinated, cross-sector strategy including increases in operational research funding levels. Within this strategy the role of the PGSF should be to focus on generic, underpinning social research.

The panel believes that the output should retain its special focus on supporting research of particular relevance to Maori development aspirations (although once again, Maori aspirations should not be seen as being supported only through this output). The panel supports continuation of the current research strategy for the social sciences, which targets a proportion of funding for such research.

***Output Fourteen: Earth Resources and Processes***

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 14.5 | 20.1 | **23.0** | 26.0 | **+59%** |

The earth resources output funds research which provides information needed for the utilisation of mineral resources, responsible land use, prevention of environmental damage, and mitigation of the effects of natural disasters. The current foci of the majority of the research in this output is into the three broad underpinning areas of regional geology and geophysics, tectonics, and processes and hazards. These are seen as particularly appropriate from a public research investment perspective.

This output contributes directly to the economy through research that underpins mineral and petroleum exploration, groundwater resource evaluation and the definition of the Legal Continental Shelf. Natural hazards research contributes directly to environmental goals on hazard mitigation.

The panel rated this output highly on research potential, ability to capture benefits and research intensity. However its strategic importance was lower than that of the other environmental outputs. The decision to recommend a significant increase recognises that research in this area of science is less able to be integrated into economic outputs than that contained in the other environmental outputs.

*Output Fifteen: Land and Fresh Water Eco-systems*

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 30.8 | 37.5 | **41.8** | 46.1 | **+36%** |

This output funds a wide range of underpinning environmental research with impacts on diverse and diffuse user communities. In particular, the output provides information to support sustainable development which minimises environmental risk, human impacts on the environment and the effects of introduced pests on natural ecosystems. Research, databases, skills and infrastructure in this output provide the basis for the development of public policy in areas such as biodiversity, sustainability, and environmental protection.

Given an increasing global requirement for productive industries to become environmentally sustainable and for mitigation of environmental impacts, the generic and underpinning research funded in this output is considered by the panel to be particularly appropriate for PGSF support. The panel is however concerned to ensure that the integrity of the PGSF is maintained in line with the role described in the Strategic Statement. The PGSF should not be eroded through making up shortfalls in the funding of research that is the responsibility of Regional Councils or government departments such as the Department of Conservation.

The panel has rated research potential, ability to capture benefits and research intensity highly for this output. Strategic importance is rated moderately, principally due to the indirect connection between research in this output and the economy.

*Output Sixteen:* *Marine Environments, Climate and Atmosphere*

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 20.5 | 26.6 | **31.8** | 36.8 | **+55%** |

This output funds research which provides underpinning knowledge of New Zealand's extensive Exclusive Economic Zone (EEZ) as well as research on estuarine, coastal and near shore processes and ecology, underpinning resource management and coastal planning. In addition, climate and atmosphere research contribute to our understanding and mitigation of greenhouse gases, climate change and ozone depletion as well as providing underpinning knowledge of the climate and weather of New Zealand, with particular relevance to major productive sectors of the economy.

With New Zealand agreeing to ratify the United Nations Convention on the Law of the Sea and thus being committed to delineation of the EEZ and LCS (Legal Continental Shelf) there is a requirement for an increasing priority for marine research. Similarly, international conventions on climate change and ozone layer protection require a significant research effort in New Zealand.

The appropriateness of the PGSF funding in this output scores highly, as does research potential, ability to capture benefits and research intensity. The economic importance of the output rates moderately, reflecting the indirect connection between research in this output and the economy.

[NB in outputs 14, 15 and 16 relatively large increases are proposed in the knowledge that there may be some short term limits to research capacity. The panel considers that any such problems should be overcome over a five year period, given an appropriate funding profile, and is confident that the guidelines described in Chapter Ten of this document will ensure that quality is not compromised.]

*Output Seventeen: Antarctic Research*

Funding level

| Output funding levels in nominal millions of dollars | | | | |
|---|---|---|---|---|
| **1995-96 funding level (estimated)** | **2000-01 (290 scenario)** | **2000-01 (330 scenario)** | **2000-01 (370 scenario)** | **Change from 95-96 (330 scenario)** |
| 1.9 | 2.4 | **2.9** | 3.5 | **+53%** |

In order to take a full part in the governance of the continent through the Antarctic Treaty System, New Zealand must maintain a credible programme of Antarctic science while displaying leadership in protecting the Antarctic environment. Quality science also materially enhances Zealand's stewardship of the Ross Dependency.

The primary scientific reason for investing in the Antarctic is however for its contribution to understanding the environment. The science undertaken there is seen as largely remote from the immediate economic and social goals of the nation, and the output's strategic importance was consequently rated low in comparison to other outputs. However research potential, ability to capture benefits, research intensity and appropriateness of PGSF funding are all rated high. The nett result is a view that Antarctic research funding should increase, although the extent of practicable increase will depend on the capacity of the infrastructure in the Antarctic.

**Commentary on broad trends in the results**

Several significant trends are evident in the results set out above. The strongest trend is a shift in funding way from outputs concerned primarily with economic development, and toward those concerned with establishing social and economically oriented knowledge bases. This shift is opposite to the 1992 result. As already explained, the shift is partly due to a greater recognition of social and environmental goals but it is also due to more explicit consideration of the concept of "public good" in the current review, ie the appropriateness of PGSF funding.

A further strong trend, in this instance in common with the 1992 STEP review, is the continuing fall in the proportion of funding going to the traditional agricultural outputs. The panel emphasises that it still considers these areas of science to be important. However, their funding has historically been disproportionally high and the relative fall largely represents a correction of that situation. Despite the relative fall and with one minor exception, one major difference from 1992 is that funding for these outputs is at least held at the existing absolute level for the "medium" funding scenario. The panel believes that result to be extremely important in providing an opportunity for key capability to be

maintained.

There are other trends evident in the results but they are not as strong as those identified above. In general the panel has treated infrastructure outputs more favourably than in 1992, reflecting their underlying contribution to economic output. In 1992 more emphasis was placed on the direct contribution to exports which advantages the "front line" outputs. Outputs which are contributing strongly to growth are also relatively well treated - a particular case in point being "Tourism, Commercial and Other Services".

The broad directions in the results are very firmly supported by the SPiR. It is nevertheless pointed out that the results are interim and that the opportunity to modify the conclusions exists if genuinely new information or perspectives are brought to bear.

## CHAPTER NINE: KEY SCIENCE AREAS

### Background

The Government's Strategic Statement outlines a requirement for the 1995 priority statement to identify Key Science Areas (KSAs) which are of importance to New Zealand's long-term future. As part of the overall consultation process, the SPiR has sought the views of the science community on potential KSAs. Then, in consultation with the Royal Society, the panel approached fifteen individuals to form an expert working group which was asked to review 80 KSA submissions received. The names of expert working group members are contained in Annex Nine.

After considering these submissions, the expert group derived a list of themes which were presented to the SPiR, which selected a final list of proposed KSAs and developed them further for presentation in this document. Submissions are now sought on the proposed KSAs, providing the information specified below in the SPiR's definition of their requirements. Prior to the panel finalising its report to the Government, members of the expert working group, and others with specialist knowledge in the KSAs concerned, will be asked to assist in developing KSA statements in more detail.

### Definition

The Government's Strategic Statement makes the following comments about KSAs:

"As well as allocating funding into a socio-economic framework, the Government wishes to be able to identify and ensure access to important areas of research and of science capability. The emphasis will be on securing long-term capability in critical areas which may not be created or preserved by expressing priorities through a purely socio-economic framework. Often these core capabilities will be in areas which have wide socio-economic applications.

It is not proposed to establish an *a priori* and comprehensive framework for this purpose, but a number of key strategic science areas will be identified, described in scientific terms, and interlinked with particular outputs. It is anticipated that these will be described in the final priority statement. These key science areas are likely to be strategic, cross-sectoral and multi-disciplinary in nature".

KSAs address issues of *long term* importance to New Zealand. Identification of KSAs will assist in identifying where gaps exist between actual and desirable levels of capability, and send signals through the wider science system so as to allow these gaps to be closed.

The SPiR has developed an expanded definition of what is required to identify KSAs:

> **Key science areas need to be specified from two points of view (and both elements are necessary).**
>
> **a** **Description of the broad purpose to which a key science area is directed. This purpose should *not* be confined within particular outputs but should be related to the general purpose and goals of the PGSF. Purposes may**

**also be cross sectoral.**

b **Description of the broad types of scientific capabilities which are important to achieving the defined purpose. These capabilities should in general be science based, cross-output in character (i.e. not confined within particular outputs) and multi-disciplinary.**

## Criteria applied

In preparing a proposed list of KSAs the panel decided to focus especially on science areas with a strong cross-output element and those with a dominant reliance on PGSF funding. This resulted in the elimination of some areas of capability which were nevertheless considered to be important in a wider context, eg capabilities relating to biosecurity were not considered because biosecurity is predominantly a Government matter which should be funded directly by the departments involved.

## List of proposed KSA titles

The panel has developed a preliminary list of proposed KSA titles, based in part on stakeholder submissions, but principally on the deliberations of the expert working group. Proposed KSAs are described in full in Annex Five and their titles are as follows:

1 Knowledge of New Zealand's Biodiversity

2 Evaluation of the Economic Exclusion Zone and Legal Continental Shelf

3 Natural Products from New Zealand's Flora, Fauna and Primary Processing Industries

4 Biotechnical methodologies

5 Maori Knowledge and Development

6 Biological Hazards Management

7 Natural Physical Hazards

8 Intelligent Production Systems

9 Improved Processing Technology, including Food

10 Clean Technology

11 Sustainable Production Systems

12 Social Equity

## Interaction of KSAs with output funding levels

The panel's view is that funding levels should not be directly associated with KSAs. Doing this would create inappropriate management difficulties for the Foundation in dealing with multiple (and potentially conflicting) funding criteria. However, it is appropriate to review output funding levels to ensure that consistent signals are being given. It would for example be inappropriate to recommend a decline in an output which was the principal funding source for several KSAs.

To enable a consistency check to be applied the panel has developed the following table which shows the *major* correlations between outputs and KSAs. Minor correlations are not shown. To simplify the presentation the following rough scale is used:

\+ minor impact

● major impact

This analysis is shown in Table Seven. While rather crude, it indicates that KSAs should be especially carefully considered when finalising recommendations on the outputs listed below. However these considerations might be best applied to developing research and cross-output strategies, rather than to establishing output funding levels. The outputs most affected are:

1. Animal Industries

2. Dairy Industries

4. Horticultural, Arable and Other Food and Beverage Industries

5. Forestry and Forest Product Industries

6. Fisheries and Aquaculture Industries

7. Manufacturing Industries and Industrial Technologies

15. Land and Fresh Water Eco-systems

16. Marine Environments, Climate and Atmosphere

## Next steps

Based on submissions as a result of the discussion paper, the panel's next step will be to confirm the number and titles of the KSAs. It is stressed that the panel has no set number of KSAs in mind and the final list could be larger, smaller or the same in number.

The detailed descriptions will then be reconfirmed through the expert working group and the implications for the five-year output funding targets reconsidered.

**Table Seven: Relationship of KSAs to outputs**

| Output / KSA | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Biodiversity** | + | + | + | + | + | + | + | + | | | | | + | + | ● | ● | ● |
| **EEZ** | | | | | | ● | | | | | ● | | | ● | ● | ● | |
| **Nat Products** | ● | ● | ● | ● | ● | ● | ● | | | | | | | | ● | ● | |
| **Biotech** | ● | ● | | ● | ● | ● | + | | | | | | + | | + | + | |
| **Maori devlpt** | ● | ● | | ● | ● | ● | | ● | | | | | ● | ● | ● | ● | |
| **Bio hazards** | ● | ● | ● | ● | ● | | | ● | | | | | ● | | ● | ● | |
| **Phys Hazards** | + | + | + | + | + | + | + | + | + | + | + | + | + | ● | + | + | |
| **Intell prodn** | ● | ● | | ● | ● | ● | ● | + | + | | | | + | | | | |
| **Imp process** | ● | ● | | ● | ● | ● | ● | | | | | | | | | | |
| **Clean tech** | ● | ● | | ● | ● | ● | ● | | | + | + | + | + | | + | + | |
| **Sust Prodn** | ● | ● | ● | ● | ● | ● | ● | | | | + | | + | | + | + | |
| **Social** | + | + | + | + | + | + | + | + | + | + | + | + | ● | + | + | + | |
| **Total impact** | ● | ● | + | ● | ● | ● | ● | + | | | + | | + | + | ● | ● | |

\+ Minor impact ● Major impact

## CHAPTER TEN: GUIDELINES FOR ALLOCATION

The panel has reviewed the guidelines for allocation developed by the Strategic Consultative Group on Research and approved by the Government in its Strategic Statement. An expanded set of proposed guidelines is set out below:

### Research strategies

Research strategies were first introduced in 1993/94 in order to guide allocations of funding within each (then) science area. The Foundation should again implement the priorities arising from the current priority-setting process by developing output level research strategies in consultation with both science providers and science users. The panel also recommends that the Foundation develop an appropriate methodology, addressing the same factors as used in determining relative priorities between outputs, to determine the appropriate balance of funding between topic areas within outputs.

Research strategies should:

- ensure a balance of economic, environmental and social research as required by the priority statement;
- adopt a format and contents guide which ensure that all strategies cover the same essential elements, but the scope for output-specific issues to be covered as well;
- be consistent with the priority statement in all respects;
- focus on implementation rather than policy development, with particular attention given to the management of funding profiles over the five-year period and the most effective utilisation of a available and developing provider capability; and
- encourage the other sectors, including the private sector, operational government departments and regional councils, to increase their own provision and funding of research in complementary relationships with the PGSF, without penalising increases in funding from these other sources.

### Cross output themes and strategies, Key Science Areas, and National Science Strategies (NSS)

Some confusion continues to be evident about National Science Strategies (NSS) and their interaction with priority setting. It is noted that:

- The NSS policy is not comprehensively applied to all science, but is applied selectively and for strictly limited periods to areas of science which are:
    - nationally important;
    - typically funded from several sources i.e. *not* just the PGSF; and

- are in clear need of *improved coordination* for effective results.

- NSS Committee activities are purely advisory and consultative i.e. these activities are not permitted to over-ride the authority and accountability of funding agencies such as FRST.

- Nevertheless if an area of science is important enough to warrant NSS status, it is also important enough to warrant cross reference in the Government's priority statement. A way in which this might be done is set out below.

Looking at the PGSF only, the panel's view that there are issues which cannot be dealt with satisfactory only in the context of individual outputs, and which therefore require a cross-output approach. It is the panel's view that issues of this type should be characterised as *Cross Output Themes*. In the context of such themes:

- FRST might be required to develop a Cross Output Theme strategy for each theme which provides broad guidelines for dealing with the theme at output level, stipulates those outputs to which the theme is applicable and sets cross output targets or emphases.

- It would be appropriate to include all NSS topics as Cross Output Themes, unless the NSS topic is entirely dealt with within one output.

- Cross Output Themes should be used sparingly i.e. only where a strong case for specification exists.

- At this stage Key Science Areas should continue to be developed separately, and only integrated with Cross Output Themes once the full science and funding implications have been worked through (see the next Chapter for the proposed process for further development of KSAs).

Based in its work to date and bearing in mind the Government's Strategic Statement, the panel at this stage recommends only the following as Cross Output Themes:

- Support of Maori development (across all outputs).

- Development of a body of knowledge on social indicators and on addressing social issues (across all outputs).

- Development of a body of knowledge on the natural environmental and on addressing environmental issues (across all outputs).

- Global climate change; information and implications (NSS topic).

- The control of Possums and Bovine Tb (NSS topic).

- Sustainable land management (likely to be nominated as an NSS topic and already being examined by a high level committee established by the Government).

## Science assets including databases and collections

While the PGSF is primarily concerned with science outputs, underlying that is the need to ensure that important capabilities are developed and maintained. This need has been a primary driver for the Key Science Area (KSA) concept.

The KSA concept does not however adequately deal with the issue of maintaining important science assets in the form of databases, curations and collections. These assets require continuity of attention irrespective of short term variations in the use of these assets. This was recognised in the 1992 Priority Statement by requiring the Foundation to develop a list of nationally important science assets.

The panel considers that it is essential for an overall, national policy to be developed in this area, and not focused only on the PGSF. In the interim, it is tentatively proposed that the following steps be taken:

- the register of nationally important science assets should be continued by FRST and subjected to a thorough review over the next 18 months.;

- funding support for nationally important assets should be explicitly considered in both research strategies and Cross Output Theme strategies; and

- where adequate support for nationally important science assets cannot be assured through normal programmes bid to FRST, FRST should arrange for such support to be provided through a dedicated programme i.e. one which has as its objective the satisfactory maintenance of the database, or collection.

## General guidelines

There are a range of other guidelines which the panel believes should be applied by the Foundation in inviting and assessing proposals for PGSF funding. These guidelines apply at a relatively low level i.e. to individual proposals, and thus do not need to be given the status of themes. None should detract from the overall requirement of the Foundation to fund high quality, relevant bids. They include the following:

- encouragement of collaborative, cross-output research where this contributes to purchase of more effective science outputs, through careful and sensitive management of the bidding process;

- effective technology transfer to be clearly demonstrated in bids as a condition of acceptance;

- high ethical standards in PGSF-funded research;

- promotion of international networking to increase knowledge of, access to, and adaption of international research, including a requirement for successful bids to specify the level and country connections of international science linkages.

- equitable access by Maori to PGSF, by minimising barriers created by differences in cultural styles or capabilities for bid preparation;

- efficient maintenance, development and utilisation of science assets of national importance including databases and collections, both through the further extension of the *national importance* process set out in the 1992 priority statement and by ensuring that such databases are cross referenced in individual bids;

- purchase of research that is relevant to achievement of strategic outcomes and goals while also meeting required standards of scientific merit;

- where possible use of evaluation mechanisms such as market signals, cost benefit evaluation and contributions to quality of life to determine likely research benefits. Other approaches to evaluation should however be used where appropriate.

- recognition of the long term nature of returns to much research, and the need for continuity in science, by funding appropriate programmes on a longer term basis; and

- ensuring that programmes funded incorporate an understanding of likely economic, environmental and social implications of research outcomes.

## CHAPTER ELEVEN: SUGGESTIONS FOR THE FUTURE

It would be premature to say too much about priority setting in the future before the full completion of the current review. However, some views on this are emerging and these are set out below to encourage comment.

### Methodology

A particular focus of the panel's work over the past three months has been the development of a methodological base for priority setting. A strong consensus on methodology did not emerge from the 1992 priority-setting process. The panel accordingly has had to go back to first principles and start at about the point that STEP started at. This took a considerable amount of the panel's time and contributed to delays in publishing the discussion paper.

The panel's interim view is that this should not be allowed to happen again. While the methodologies set out in the present paper need further development (and especially need to be supported by better information bases) they are conceptually sound and should be endorsed as one basis for further work. MoRST should accept the primary responsibility for this further work which should be aimed at presenting future priority setting panels with a firm methodological framework supported by comprehensive information bases. As well as further developing the present methodology, international progress on methodology development should be monitored and alternative approaches explored.

In addition, the panel notes the need for better quality information, especially economic data, which can be directly mapped to the output framework, and recommends that this be developed well in advance of future priority-setting exercises.

### Further development of Key Science Areas

Because the Key Science Areas (KSA) concept is new the panel has not felt comfortable in developing it beyond an initial stage. The final outcome in regard to the current review is likely to be no more than a reasonably detailed description of each KSA (in scientific terms) and a cross-check to output funding targets to ensure no gross inconsistencies.

This is hardly sufficient.

The panel's interim view is that KSAs should be further developed over the next 2 years, and priorities *lightly* reviewed prior to the 98/99 year (this coincides with the next but one major funding round in FRST's new biennial cycle) to more comprehensively ensure consistency. With funding for the PGSF now set to steadily increase it should be possible to accommodate the impact of a more thorough review of KSAs without disturbing the broad trends that come out of the present priority review.

The panel's view is that the KSA concept itself needs further development. Coordination of this work should be the responsibility of MoRST and the outcome should be endorsed by the Government, in the form of an amendment to the 1995 priority statement. While coordination should be the responsibility of MoRST, the Ministry should be required to consult extensively with the science community and science users, and to work in close

association with the Foundation and with the Royal Society. Both of these bodies should have the right to provide an independent commentary on the outcome and those independent commentaries should be provided directly to the Minister for RS&T.

Further development of KSAs should in particular encompass:

- the further detailing of the preliminary KSA statement to further define; the capabilities involved, their current status and location, current funding and their linkages to outputs and to outcomes from the PGSF investment.

- the development of an indicative strategy for the KSA setting out where capabilities need to be strengthened or redirected and to what extent.

- an analysis of funding implications for the PGSF.

**Output framework**

Chapter Eight of this discussion paper refers to the possibilities of disaggregating the Output Framework to assist further analysis, prior to preparing a final report. There is however no suggestion that the 17 Output Framework should be altered as the basis for stating output funding targets.

The panel's interim view is that the issue of disaggregation should be considered further by both MoRST and FRST after the completion of the 1995 priority review. It would assist future priority setting if a more disaggregated analytical framework was available from the outset. This analytical framework should however be made compatible with the 17 Output Framework i.e. the two frameworks should map together exactly.

## ANNEXES

## ANNEX ONE: DETAILED DESCRIPTION OF OVERALL PROCESS

### Background

In early May 1994, the Government approved a process for reviewing priorities for the PGSF, in keeping with its announced intention to carry out a review every three years. The process was to produce a new statement with a five-year time frame i.e. looking forward from the year 1996/97 to 2000/2001.

In response to feedback on the last priority-setting round, the process has this time been divided into three main phases, and:

- an initial strategic phase, to establish an overall strategic context;
- the prioritising process itself, from mid-1994 to early 1995; and
- the implementation phase, which will include promulgation of the priorities and their expansion into detailed research strategies, to be completed by mid to late 1995 to synchronise with the issue of bidding instructions for the 1996/97 science funding round.

The phases were not expected to be purely sequential, nor was the overall process envisaged as being entirely "top down". There were to be degrees of overlap between the phases so that there was cross-fertilisation of ideas and information between them. In particular, the prioritising process was to inform, and be informed by, the phase from which the more detailed, "bottom up" research strategies were to be developed. To help ensure that this happened, the process plan was for two major panels, with overlapping membership, to be appointed to oversee separate phases of the process.

The process was to be as consultative as possible, including face-to-face meetings between stakeholders and the panel charged with overseeing the prioritising phase. The need for this type of approach was reinforced by the review of the 1992 process. That review also showed that it is necessary to carry out a separate process of consultation with Maori, in parallel with all the phases.

### The strategic phase

This phase was initiated with the appointment of the Strategic Consultative Group on Research (SCGR) in late May 1994. The task of the SCGR was to oversee the development of recommendations to the Government on a *Strategic Statement* setting directions for the Government's investment in the Public Good Science Fund (PGSF). In carrying out this task, the SCGR was asked to develop a perspective on the likely evolution of the New Zealand economy and society over the next 20 years, and from this derive the implications for the allocation of the Public Good Science Fund. The SCGR was required to consider existing and developing Government strategic policies and statements of particular relevance to RS&T in New Zealand, with particular emphasis on the "Path to 2010", the Prime Minister's State of the Nation Address of January 1994, the "RS&T 2010" statement being developed by the Minister of RS&T and the goals set out in the 1992 priority statement

which was approved by the Government.

The SCGR produced a draft strategic statement in August 1994 and received submissions on the draft. It then prepared a final report to the Government entitled "For the Public Good: Directions for Investment Through the Public Good Science Fund". This report proposed goals for the PGSF consistent with the Government's overall goal of improving living standards of New Zealanders over the long term, including sustaining and enhancing GDP growth, environmental quality and social cohesion. It also described the purpose of the PGSF as part of the total investment in Research, Science and Technology in New Zealand and its role in addressing problems which would not otherwise be addressed, and included the framework to be used to express priorities.

The Government considered the report of the SCGR, and from it derived a final Strategic Statement to guide investment through the PGSF, entitled "Science & Technology: The Way Forward 1996 -2001". This Strategic Statement was released in December 1994.

**The prioritising phase**

The Science Priorities Review Panel (known as the SPiR) was appointed in December 1994 to oversee the second principal phase of the overall process. The SPiR has been charged with developing advice on the distribution of the PGSF across 17 science areas or outputs, definition of Key Science Areas (KSAs) and specification of other non-quantitative guidelines for investment. The panel has been required to consult extensively with key stakeholders in the science user and provider communities in developing its advice.

For the purposes of determining output funding levels, the SPiR has been required by its terms of reference to develop a methodology (or set of methodologies) and report the proposed methodologies to the Minister of Research, Science and Technology, for the Minister's approval prior to application. This was done in late January 1995.

**Consultation**

As required by its terms of reference, the SPiR has consulted widely with science stakeholders from the time it first met on 14 December 1994. Immediately following the panel's first meeting, the Convenor wrote to the key stakeholders to initiate a comprehensive process comprising five key components. The SPiR has also interacted with the parallel process of consulting with Maori, which began prior to the appointment of the SCGR and has continued throughout. The five additional components of the SPiR process have been:

*1. Direct consultation with Key Stakeholders*

A list of over 350 key stakeholders were asked to comment on the key output-specific and cross-sectoral issues relevant to achieving the strategic directions and goals contained in the Government's Strategic Statement. Around 100 submissions were received, as listed in Annex 10.

*2. Output reports*

At the same time as they were asked for submissions, key stakeholders were also asked for nominations of suitable people to prepare a report on each output addressing the six key factors of the methodology. In the event, the SPiR decided to appoint a convenor and subconvenor for each output, in order to ensure a balance of perspectives across the PGSF. Convenors and subconvenors were briefed on their task by the Ministry of Research, Science and Technology and consulted with stakeholders in their own output sectors. Seventeen output reports were supplied to the SPiR by the end of February 1995. A list of convenors and subconvenors is in Annex Eight. Copies of the full output reports are available from the Ministry of Research, Science and Technology on request.

*3. Key Science Areas*

Submissions were also sought from key stakeholders to assist in the identification of Key Science Areas or KSAs (described in Chapter Nine of this document). Respondents were asked to supply a list of no more than five topics, with one sentence descriptions and half a page of supporting text, using a prescribed format, for each nominated topic. Eighty submissions on KSAs were received, as listed in Annex Eleven.

To assist in deriving proposed KSAs the SPiR, in consultation with the Royal Society, appointed an expert working group to sift the submissions received. The expert working group considered the submissions and met to draw up a list, which was presented to the SPiR, further developed and is included in this paper for comment.

*4. Delphi Survey*

The SPiR wanted to ensure the widest possible input into determining key elements of the quantitative methodology, in order to ensure that they were as robust as possible. In particular, the panel wanted to gain a wider perspective of appropriate factor scores to be inserted into the methodology. A consultative group of approximately 100 was therefore compiled, comprised as follows:

for each output in the framework:

| | |
|---|---|
| science providers | 2 |
| users | 2 |
| giving a total of | 68 |

plus 10 to 15 scientists with no particular output affiliation

plus 10 to 20 other contributors representing other interests.

Victoria University was contracted to survey this group, confidentially on behalf of the SPiR. In the event, 60 of the group participated in the survey. The SPiR found the results of the first round to be useful as they were and decided against proceeding with further rounds of the Delphi.

*5. Information and analysis*

The SPiR also gathered a substantial amount of relevant existing information and contracted a number of agencies to provide additional analysis and comment. The full range of additional information considered by the panel is listed in Annex Six.

**Decision making**

The SPiR absorbed all the consultation and other information inputs received and met for four days during late February - early March to apply the methodologies to the questions they had been asked to consider. These meetings were held in the Decision Support Centre of Victoria Link Ltd, a subsidiary of Victoria University in Wellington. The technology in this centre enabled the panel to carry out the necessary scoring, to discuss views as they emerged and to reach consensus in an efficient manner. These sessions also involved the use of an Excel spreadsheet to enable use of the quantitative methodology.

**Implementation phase**

Part of the implementation phase will be mechanical, i.e. issuing a priority statement. It is proposed to again accompany the priority statement with a Government publication similar to "Investing in Science for our Future", which was produced following the STEP process in 1992.

Priority-setting is primarily about making choices *between* different output classes of science. This contrasts with research strategies which are concerned with implementation *within* output classes. As with the last priority statement the research strategy process will need to translate priorities to the operational level.

Research strategy development will again be based on broad and comprehensive consultation within science areas, but integrated with the priority-setting phase so that there is no duplication of effort. Much of the necessary information will have already been gathered during the final stages of the review of priorities.

## ANNEX TWO: TERMS OF REFERENCE FOR THE SCIENCE PRIORITIES REVIEW PANEL

### Function of panel

1 The conduct of stage two of the review will be the responsibility of a panel to be called the Science Priority Review Panel (SPRP). The SPRP will be primarily responsible for carrying out this terms of reference and recommending priorities to the Government, through the Minister of Research, Science and Technology.

2 Membership of the SPRP will be determined by Cabinet.

3 The SPRP will be required to establish formal advisory groups and informal networks to assist consultations and expert input from the science community and science users. Formal advisory groups will be established in consultation with the Minister of Research, Science and Technology.

### Background assumptions on funding levels

4 The baseline level of funding for the PGSF is $ 273m in 1996/97, excluding Non Specific Output Funding (NSOF).

[already approved by Cabinet]

5 No specific commitments have been made to levels of funding beyond 1996/97. However funding will not be less than the 1996/97 level of funding. Accordingly the panel is to develop its recommendations on the basis of a range of scenarios. The number of scenarios will be at the discretion of the panel but should include:

a At the lower bound, continuation of funding at the 1996/97 level.

b At the upper bound, a smoothly increasing profile of funding which is consistent with the Government's commitment to achieving total science funding of 0.8% of GDP by the year 2010.

### Scope

6 The overall role of the panel will be to develop advice to the Government on the specific priorities to apply to investment of the Public Good Science Fund (PGSF) for the five year period beginning in FY 1996/97. In doing so, it will be required to work within the context of the Strategic Statement approved by the Government.

7 The panel will be required to:

- develop a methodology (or set of methodologies) for recommending quantitative science priorities, i.e. allocation of funding into specific output categories, based on the output framework contained in the Strategic Statement, and using the methodologies suggested by the Strategic Consultative Group on Research (SCGR) as a starting point;

- report the proposed methodologies to the Minister of Research, Science and Technology, and have them approved by the Minister prior to application;

- apply the approved methodologies to the development of quantitative recommendations;

- develop non-quantitative guidelines for the application of the PGSF investment;

- identify key science areas to be overlaid on the quantitative science priorities. These areas are likely to be cross-sectoral, multi-disciplinary, long-term and opportunity driven.

- publish a discussion paper on science priorities to provide a basis for wider consultation; no later than early March 1995; and

- publish a final report containing advice to the Government on science priorities by the end of April 1995.

8 The final recommendations will include advice on the overall scope of and strategic directions within, the output level research strategies the development of which is to be coordinated by the Foundation. The panel may make recommendations on priority topics, or coordinating strategies, which have relevance to several or all science strategies. Further guidelines relating to the development of science strategies are given in the Government's Strategic Statement.

9 In carrying out its task, the SPRP will be expected to:

- Operate within the goals and guidelines and in accordance with the priorities framework set out in the Government's Strategic Statement;

- Consult with key stakeholders (users, providers, funders and policy-makers) as to the appropriate content of, and priorities within, the final report. Methods of consultation are to be established which allow for networking with stakeholders throughout the second stage process; and

- Incorporate input from the complementary process of consultation with Maori being coordinated by the Ministry of Research, Science and Technology.

## ANNEX THREE: DETAILED DESCRIPTION OF QUANTITATIVE METHODOLOGY

The strategic statement proposed a methodology for assigning funding levels to outputs across the 17 output framework based on six "key factors", or criteria, as follows:

F1 Strategic importance of each output

F2 The potential of science in each output

F3 The potential of users to capture benefits

F4 Research capacity

F5 Research intensity

F6 Appropriateness of PGSF funding.

However, the SCGR did not suggest how these factors should be weighted or combined to produce a relative "score" for each of the 17 outputs. This became a matter which SPiR debated at length.

An extended description of each of the six key factors is as follows:

1 Strategic Importance

This factor represents the potential contribution of the output to the achievement of the Government's socio-economic goals, as stated in the Strategic Statement.

*Considerations*

- whether the output contributes to single for multiple goals, and major or minor goals; taking account of the relative importance of those goals.
- urgency, likelihood of crises.
- opportunity cost of not doing research.
- local relevance, uniqueness to New Zealand.
- synergy, contribution to socio-economic benefits in other outputs.
- *for outputs which are predominantly oriented to the environment* impact on environmental issues.
- *for outputs which are predominantly oriented to economic development,* the extent and nature of the impact on health and safety, social or cultural issues.

- *for outputs which are predominantly oriented to economic development,* the projected contribution to GDP of the sector(s) with which the output is associated.

2 R&D Potential

This factor relates to the likelihood that research will achieve results.

*Considerations*

- likelihood of important breakthroughs i.e. step change in knowledge.
- maturity of current technology and thus likely effectiveness of further investment.
- probability of success in a generic sense i.e. how difficult it is to produce useful results based on "track record"?
- pluralism and innovation in lines of enquiry and in techniques, in this general area of science.
- likelihood of advances occurring in New Zealand compared with similar science efforts in other countries.

3 Ability to Capture Benefits

This factor represents the extent to which users of research in the output have the ability (or willingness) to capture its benefit, and their timeliness in doing so.

*Considerations:*

- awareness of users of the potential of the research in the output.
- whether research effort is guided by a strategy agreed by the user sector(s).
- technology transfer: networks between scientists and users; multiplicity of transfer mechanisms: rapidity of exploitation.
- effectiveness of capture of Intellectual Property Rights.
- technology capability of users vis-a-vis overseas counterparts.
- extent of user investment in research as a complement to PGSF investment (user investment is useful quantitative indicator of the technological capabilities of users i.e. the more users invest themselves the more likely they are to be able to utilise the results of PGSF research).

Note: This factor may be difficult to assess for sectors which have no identifiable "user" except in a generic sense e.g. environmental and basic knowledge outputs in particular. The

word "capture" is not intended to imply capture for the sole use of a particular user.

4 R&D Capacity

This factor represents the quantity and quality of resources available to support current and future research.

*Considerations:*

- current level of research skills and supporting infrastructure, i.e., facilities and equipment.
- ability to increase level of research skills.
- capability in terms of skills, experience, creativity, facilities in comparison with researcher overseas.

Note: This particular factor should be regarded as highly time dependent in the sense that it becomes progressively less important as lead times become longer. For example it amy be overwhelmingly important if the time horizon is one year but may be of zero impact if the time horizon is (say)15 years.

5 Research Intensity

The extent to which the sector is dependent on investing in research, e.g., for leading edge technology, for success.

*Considerations:*

- the technology intensity of the sector.
- levels of research investment relative to other sectors, especially benchmarked against other countries.
- extent of reliance on technology for competitive edge.
- type of research required; inherently low cost or high cost?

6 Relative Contribution of PGSF Funding

The extent to which research in the output should be funded from the PGSF compared to other sources.

*Considerations:*

- comparison of funding from PGSF and non-PGSF (especially private) sources, with emphasis on what the balance ought to be rather than what it is.

- extent to which the benefits of research in the output can be captured by identifiable groups or individuals as opposed to being public good in character, i.e.m, appropriability.

- whether there are intractable difficulties in mobilising non-PGSF- funding, e.g., structural factors, high transaction costs.

- with the Government policy in related areas including any requirement on the New Zealand Government to meet international e.g. treaty) obligations.

- whether research is generally long term (more suitable for PGSF funding) or short term.

- extent to which research is generic in character i.e., of wide applicability, rather than specific to particular ends.

*Design of a Formula*

The panel considers that the six key factors fall into primary and secondary categories.

Primary factors are: F1 Strategic importance; and
F6 Appropriateness of PGSF funding

while factors F2-F5 are secondary. This suggests a trial formula for assessing the overall weight which should be given to each output:

Output weight = $F_1 * (W_2F_2 + W_2F_3 + W_4F_4 + W_5F_5) * F_6$

where $F_1$ .. $F_6$ are the key factors listed above and $W_2$ .. $W_5$ are the relative weights assigned to factors $F_2$ to $F_5$.

Nearly all the panel's trial scoring exercises were carried out using this formula.

The output weights were then normalised to sum to 1, and multiplied by the total funding level for the PGSF to give funding per output.

*Establishing a score for strategic importance*

Strategic importance is in itself a compound factor. The panel began by scoring the various goals given in the strategic statement, using the score sheet below:

*SCORE SHEET*

*Step 1*

*Excluding the two over-arching Science Goals, the remaining 13 goals for the PGSF are grouped into three sets:*

*A Economic Goals*
*B Environmental Goals*

*C Social Goals*

*You have 100 points to allocate. First, allocate the 100 points between the three sets of goals based on your view of the relative importance of each set to the overall role and purpose of the PGSF.*

| Goal Sets | Aggregate Score |
|---|---|
| *A: Economic* | _____ |
| *B: Environmental* | _____ |
| *C: Social* | _____ |
| *Total:* | *100* |

Step 2 was to establish the contribution made by each output to each set of goals in Step 1. In assessing the contribution of each output to the economic goals, GDP contributions were taken into account. For this the score sheet overleaf was used:

## *SCORE SHEET*

*Step 2*

*For each set of goals (economic, environmental, social) decide the contribution made by each output. You have 100 points to spread across each goal set.*

| | | *Economic* | *Environmental* | *Social* |
|---|---|---|---|---|
| | ***Primary Industries*** | | | |
| *1* | *Animal Industries* | | | |
| *2* | *Dairy Industries* | | | |
| *3* | *Forage* | | | |
| *4* | *Horticulture, Arable & Other Food & Beverage industries* | | | |
| *5* | *Forestry and Forest Product industries* | | | |
| *6* | *Fisheries & Aquaculture industries* | | | |
| | ***Manufacturing*** | | | |
| *7* | *Manufacturing industries & Industrial Technologies* | | | |
| | ***Services and Infrastructure*** | | | |
| *8* | *Tourism, Commercial and Other Services* | | | |
| *9* | *Information & Communications Networks and Services* | | | |
| *10* | *Construction* | | | |
| *11* | *Energy* | | | |
| *12* | *Transport and Distribution Systems* | | | |
| | ***Social Sector*** | | | |
| *13* | *Society and Culture* | | | |
| | ***Biophysical Environment*** | | | |
| *14* | *Earth Resources & Processes* | | | |
| *15* | *Land & Fresh Water Ecosystems* | | | |
| *16* | *Marine Environments, Climate & Atmosphere* | | | |
| *17* | *Antarctic Research* | | | |
| | | *100* | *100* | *100* |

The strategic importance (Si) for each output was then calculated in the spreadsheet from:

$S_i$ = Economic contribution for output 1 x weight of economic goal set

+ Environmental contribution for output 1 x weight of environmental goal set

+ Social contribution for output 1 x weight of social goal set.

The strategic importance scores were normalised to sum to 1.

9 The weights attached to secondary factors $F_2$ - $F_5$ were then established using the following score sheet:

*SCORE SHEET*

*Step 3*

*Assign weights to each of the four factors below.*

| | |
|---|---|
| *1* | ***Potential of Science in each Output***<br>*(The likelihood that research will achieve results)* |
| *2* | ***Potential of Users to Capture Benefits***<br>*(The extent to which users of research in the output will capture its benefit, and their timeliness in doing so)* |
| *3* | ***Research Capacity***<br>*(The quantity and quality of resources available in New Zealand to support current and future research)* |
| *4* | ***Research Intensity***<br>*(The extent to which the sector is dependant on investing in research for its success)* |

| *Key Factor* | *Score* |
|---|---|
| *1* | |
| *2* | |
| *3* | |
| *4* | |
| ***Total*** | ***100*** |

Again, the panel's mean score was entered into the spreadsheet for each weight, after repeated rounds of discussion and rescoring. In the event, capacity was weighted at zero, since it was considered to be a transitional issue rather than having an impact on the result itself. The actual relative weightings arrived at are shown in the following table.

The panel then scored the factors in turn, with discussion and rescoring as needed. More discussion and more rounds of scoring occurred when the scoring ranges were widest. Score sheets were as follows:

*SCORE SHEET (One for each of the factors 3 - 6)*

*Steps 4 - 7*

*Score each output for (Factor 3 - Factor 6), on a scale 0-10.*

| *Output* | *Description* | *Score* |
|---|---|---|
| *1* | *Animal Industries* | |
| *2* | *Dairy Industries* | |
| *3* | *Forage* | |
| *4* | *Horticulture, Arable & Other Food & Beverage industries* | |
| *5* | *Forestry and Forest Product industries* | |
| *6* | *Fisheries and Aquaculture Industries* | |
| *7* | *Manufacturing Industries & Industrial Technologies* | |
| *8* | *Tourism, Commercial and Other Services* | |
| *9* | *Information and Communications Networks & Services* | |
| *10* | *Construction* | |
| *11* | *Energy* | |
| *12* | *Transport & Distribution Systems* | |
| *13* | *Society & Culture* | |
| *14* | *Earth Resources & Processes* | |
| *15* | *Land & Fresh Water Ecosystems* | |
| *16* | *Marine Environments, Climate & Atmosphere* | |
| *17* | *Antarctic Research* | |

At this point the first phase of the exercise was complete, i.e. a set of raw scores existed which could be used to calculate funding per output on a "first cut" basis, at each of the two PGSF funding scenarios of $290m and $370m.

## ANNEX FOUR: THE RESULTS OF APPLYING THE QUANTITATIVE METHODOLOGY

Introduction

The results of applying the quantitative methodology consist of:

- assessments of each of the key factors by output, incorporating an initial assessment of the relative importance of the goals set out in the Government's strategic statement.

- weightings for each of the secondary factors (those other than strategic significance and the appropriateness of PGSF funding).

- the outcome, output by output and for the higher of the two funding scenarios, of aggregating the factor scores through the model.

  [Outcomes have been generated for both the higher and lower funding scenarios but the higher results are more useful for highlighting trends for discussion. The results for the intermediate scenario were determined by interpolating between the other two scenarios]

- a limited range of sensitivity tests on the outcome to enable the significance of particular input variations to be further explored.

The results presented do not incorporate the effect of applying transitional factors such as restrictions on the rate of growth or decline of individual outputs. In the event the panel has decided to stop running the model at the point of producing "model" scores which exclude transition factors. Transitional considerations have been included in the overall analysis dealt with in Chapter Eight.

In applying the quantitative methodology, the capacity factor has been deleted from the calculation. This is because the panel's view is that capacity is a transitional rather than a fundamental criterion. Over time capacity can be adjusted.

The factor 'scores' set out below represent the arithmetic mean view of the panel. Scores have been developed using the Decision Support Centre at Victoria University. The Centre enables scores to be entered simultaneously by the participants in the scoring process, and means and ranges calculated and displayed back to the participants. Each factor was scored in approximately 5 separate sessions spreading over several weeks. In each session quantitative assessments were discussed, debated and argued within the panel and rescored until no further significant shift in the mean score was discernible. The scoring process was informed by a number of inputs including:

- The convenor reports for each output.

- External reports from two independent consultants (Infometrics, NZIER) on the linkage of outputs to projections of future contribution to GDP.

- Stakeholder submissions.
- Reports commissioned from both MoRST and FRST on a number of elements.
- The collective knowledge and experience of the panel itself.

**Use of Decision Support Centre and Spreadsheet Calculations**

Decision-making based on multiple criteria is made much easier by the use of a computer. Accordingly, the panel met several times in the Victoria University Decision Support Centre, where panel members each had a PC networked into a suite of decision support software programmes.

The panel was able to:

- enter their own score against each of the six factors
- view the aggregate scores of the panel, including the scoring range and mean score
- debate the results in between repeated scoring trials.

The panel was also able to enter text material in relation to their scoring decisions, which could be consolidated into the panel's reports.

As agreed scores became available during the panel's deliberations, they were fed into a spreadsheet set up on a stand alone PC in the same room. The effect of each round of scoring on the final result (i.e. dollar allocations per output) could be viewed by the panel very quickly, allowing numerous iterations and sensitivity checks to be carried out.

The results below for the individual factors are set out in blocks, with a brief explanation beside each block, to enable the information to be presented in a reasonably condensed form.

The aggregate results i.e. "ideal" funding levels are set out in the form of the broad strengths and directions of change from current (1996/97) funding levels. This approach has been adopted for the following reasons.

- It would be misleading to attach too much significance to the absolute scores. The exercise is principally about relativities and broad directions of change. While the quantitative methodology is conceptually acceptable the scoring of the individual factors is still subject to considerable uncertainty.
- Presenting the results in condensed and stylised form makes it easier to highlight the impact of sensitivity testing.

The following system has been used to represent the relative results:

++ strong relative increase indicated

| | |
|---|---|
| + | small relative increase indicated |
| 0 | no significant change |
| - | small relative reduction indicated |
| -- | strong relative reduction indicated |

Factor 1: Strategic Significance

Assessment of this factor has been the most complicated part of the process and also that involving the greatest degree of subjective assessment.

The first step has been to estimate the strategic significance of the PGSF goals themselves. The outcome of doing this is set out in the table below in terms of groups of goals, because this has been the most effective way of both estimating and applying the scores. The table sets out three blocks of results:

- the result of the initial assessment carried out by the SCGR.
- the result of the external survey of 60 selected respondents (the so-called "delphi" group).
- the assessment by the panel itself.

**Weightings of sets of strategic goals**

**% weighting for strategic significance**

| Goals[1] | SCGR report | delphi survey (mean) | SPiR assessment |
|---|---|---|---|
| Economic | 45-55 | 48.2 | 50 |
| Environment | 25-35 | 31.8 | 30 |
| Social | 15-25 | 19.9 | 20 |
| | 100 | 99.9 | 100 |

Notes 1 Taken from pp 7 & 8 of the Government's Strategic Statement

A feature of these results is the close correspondence between the different sources.

Despite the close correspondence the panel has elected to regard the weighting of strategic goals as a key sensitivity. This is because assessment of strategic goals is most properly a matter for the Government itself. It is accordingly essential that the Government has the opportunity to see how sensitive the results are to this input.

The second step has been to evaluate the relative contribution of each output to the three sets of goals. In making the assessment of contribution to economic goals the panel has placed particular weight on the future makeup of GDP. The table below accordingly lists GDP attributions generated from data from two independent consultants. The attributions are based on projections, but these show relatively little shift from the pattern in the base year (1991). The attributions have been modified by the panel to reflect factors other than GDP attributions, taking account of the likely patterns in the year 2005.

An issue discussed by the panel has been that of whether attribution to GDP should be the primary quantitative indicator of contribution to economic goals, or whether this attribution should be modified by the direct contribution to exports. Although cognisance of the contribution to exports was made, it was decided not to directly factor in a modifier for exports, on the grounds that with an open economy, exports are not of greater importance than other types of economic activity.

The assessments of contribution to environmental and social goals are necessarily more subjective, but based on the whole range of information available to the panel.

The tables below list the results for each output. The mathematical formula for calculating this result is set out in Annex Three.

## GDP figures provided to SPiR

| Output | GDP attributions provided to SPiR | |
|---|---|---|
| | from NZIER (1994) | from Infometrics (1995) |
| 1 Animal | 5.44 | 4.8 |
| 2 Dairy | 2.4 | 2.1 |
| 3 Forage | 1.6 | 1.0 |
| 4 Hort | 4.6 | 4.0 |
| 5 Forestry | 5.1 | 6.3 |
| 6 Fishing | 0.5 | 0.3 |
| 7 Mntrg | 11.0 | 8.7 |
| 8 Tour & Ser | 34.2 | 40.0 |
| 9 Inform | 5.6 | 3.4 |
| 10 Construct | 4.0 | 4.3 |
| 11 Energ | 3.15 | 2.75 |
| 12 Transport | 6.85 | 5.3 |
| 13 Society | 13.0 | 15.0 |
| 14 Earth | 2.1 | 1.6 |
| 15 Lan | .16 | .15 |
| 16 Marine | .2 | .2 |
| 17 Antarctic | .1 | .1 |
| | 100 | 100 |

Notes:

1. There is a particularly large difference between the attribution of GDP to Output 13 and the assessed contribution of the output to economic goals. This is because Output 13 has been attributed with that part of GDP representing central Government services. The panel took the view that this attribution was not relevant for allocating PGSF funds.

**Scores for contributions of outputs to goal sets**

| Output | Contributions to goals | | |
|---|---|---|---|
| | to economic goals | to environ goals | to social goals |
| 1 Animal | 5.9 | 4.3 | 3.9 |
| 2 Dairy | 3.5 | 3.3 | 3.4 |
| 3 Forage | 2 | 5.2 | 2.5 |
| 4 Hort | 5 | 4 | 4.8 |
| 5 Forestry | 5 | 4.8 | 4.4 |
| 6 Fishing | 1.5 | 3.3 | 4.0 |
| 7 Mntrg | 10.3 | 4.5 | 5.1 |
| 8 Tour & Ser | 38.9 | 3.3 | 10.0 |
| 9 Inform | 4.8 | .6 | 5 |
| 10 Construct | 4.4 | 2.2 | 3.4 |
| 11 Energ | 3.3 | 5.3 | 3.4 |
| 12 Transport | 6.3 | 4.5 | 5.6 |
| 13 Society | 1.8 | 3.7 | 29.3 |
| 14 Earth | 2.9 | 12.6 | 4.6 |
| 15 Land | 2.1 | 20.0 | 5.1 |
| 16 Marine | 2.1 | 16.5 | 5.1 |
| 17 Antarctic | 0 | 1.6 | .3 |
| | 100 | 100 | 100 |

**Overall scores for strategic values of outputs**

| Output | Overall strategic value |
|---|---|
| 1 Animal | 4.0 |
| 2 Dairy | 2.5 |
| 3 Forage | 2.1 |
| 4 Hort | 3.5 |
| 5 Forestry | 3.6 |
| 6 Fishing | 1.5 |
| 7 Mntrg | 6.7 |
| 8 Tour & Ser | 21.6 |
| 9 Inform | 3.3 |
| 10 Construct | 2.9 |
| 11 Energ | 2.7 |
| 12 Transport | 4.3 |
| 13 Society | 14.8 |
| 14 Earth | 6.4 |
| 15 Land | 10.4 |
| 16 Marine | 8.6 |
| 17 Antarctic | 1.1 |
| | 100 |

**Weightings of factors used in the quantitative methodology**

| Factor | Weighting (%) |
|---|---|
| R&D Potential | 45 |
| Potential of Users to Capture Benefits | 30 |
| Research Capacity[1] | 0 |
| Research Intensity | 25 |

[1] The panel decided to use capacity as a transitional factor only, not as an input to the quantitative methodology.

## Factor 6: The appropriateness of PGSF Funding

Along with strategic importance, the appropriateness of PGSF funding is a key factor. The individual scores for each output in the range from 0 to 1.0 are thus set out in the table below. However, supporting comments are provided for groups of outputs rather than for each output.

| Output | | Level of score | Comment |
|---|---|---|---|
| 16. | Marine & Atmosphere | **High** | These outputs are all characterised by having few direct links to users who might be expected to fund the research. This is in part because all these outputs contain a strong element of underpinning research on the natural environment. Earth resources receives the lowest score within the group because it contains a proportion of research which in principle should be funded by users such as the mining industry and the insurable industry. |
| 17. | Antarctic | | |
| 15. | Land & Water | | |
| 14. | Earth Resources | | |
| 3. | Forage | **Medium** | These outputs are predominantly focused on economic development and there is accordingly an expectation that users should contribute substantially to the national research investment. However, it is recognised that in some of these outputs the user sector is structurally disaggregated and there is consequently a rationale for public investment to be relatively strong. This argument is least applicable for Forestry, Manufacturing and Dairy where at least parts of the sector are characterised by large, technologically capable commercial entities. |
| 6. | Fishing | | |
| 4. | Horticulture | | |
| 1. | Animals | | |
| 5. | forestry | | |
| 7. | Manufacturing | | |
| 2. | Dairy | | |
| 11. | Energy | **Low** | The final group of outputs is scored relatively low for a number of different reasons. In the case of the infrastructural outputs it is because the sectors are in the main dominated by large companies well able to fund research. The low rating for Tourism and Services reflects the dominant component of commercial services making up the sector covered by the output. Finally the low rating for the Society and Culture Output reflects the position of the Government itself as the major user, and the need for this to be reflected in the direct investment of departments and Crown agencies. |
| 12. | Transport | | |
| 10. | Construction | | |
| 13. | Society | | |
| 9. | Information | | |
| 8. | Tourism & Services | | |

Secondary Factors (Factors 2, 3 and 4)

These factors are the science potential, the ability of users to realise benefits, and research intensity. The final scores accorded to each of these factors by the panel are summarised in the three tables below. The scores are recorded in blocks and a brief comment provided on the considerations that were influential in deciding on the scores.

It is noted that the methodology used by the panel aggregates these three factors together rather than treating them as independent factors. At least for the time being this approach is supported by the results of scoring. The panel found it quite difficult to separate the three factors and this is illustrated by some of the strong common trends evident in the three tables below:

Science potential

| Output group | Level of Score | Comment |
|---|---|---|
| 1 Animal<br>2 Dairy<br>3 Forage<br>4 Horticulture<br>5 Forestry<br>6 Fishing<br>14 Earth resources<br>15 Land<br>16 Marine<br>17 Antarctic | **High** | These outputs are all assessed as having high science potential. They are typically concerned with areas of Science in which NZ has a strong tradition and where the associated sectors have unique characteristics relative to other countries. |
| 7 Manufacturing<br>9 Information<br>13 Society<br>10 Energy | **Medium** | These outputs are assessed as being of intermediate ranking from a science potential point of view. |
| 8 Tourism & Services<br>9 Construction<br>12 Transport | **Low** | These outputs are all assessed as having low science potential. A number of reasons apply, including lack of differentiation from research being done overseas or insufficient evidence from existing research information that high potential exists. This latter point applies particularly to Output 8. |

## Ability of users to realise benefits

| Output group | Level of Score | Comment |
|---|---|---|
| 1 Animal<br>2 Dairy<br>3 Forage<br>4 Horticulture<br>5 Forestry<br>6 Fishing<br>14 Earth resources<br>15 Land<br>16 Marine<br>17 Antarctic | **High** | These outputs are all associated with user groups or constituencies with a high ability to realise benefits from the investment in research. In the case of the economic development outputs this is primarily a consequence of strong industry structures with a commitment themselves to research. For the environmentally oriented outputs the score represents a more general ability to make use of the information being generated. |
| 7 Manufacturing<br>9 Information<br>13 Society<br>10 Energy | **Medium** | These outputs represent a mixed assessment i.e. of some areas of strong user connection but others which are poor. This is for example especially the case for manufacturing which is a complex mixture of some large and technically competent companies but a very large number of small companies with poor connections to technology. In some cases structural problems have influenced the scoring and this applies for example to pricing in the energy sector. |
| 8 Tourism & Services<br>12 Transport<br>13 Society | **Low** | The low scores for these outputs are all for different reasons, but in general the panel is not convinced by the evidence that research results from NZ based research will be effectively picked up and applied. |

## Research Intensity

| Output group | Level of Score | Comment |
|---|---|---|
| 1 Animal<br>2 Dairy<br>3 Forage<br>4 Horticulture<br>5 Forestry<br>6 Fishing<br>14 Earth resources<br>15 Land<br>16 Marine<br>17 Antarctic | **High** | This rather large group of outputs is characterised by connection to sectors which are inherently research intensive i.e depend on relatively high levels of investment in r&d for successful operation and development. |
| 9 Information<br>11 Energy | **Medium** | These two outputs are intermediate in research intensity reflecting an assessment that while both sectors are technology intensive, they can rely to a significant extent on imported technology because they are infrastructural in character. |
| 8 Tourism & Services<br>10 Construction<br>12 Transport<br>13 Society | **Low** | This group of outputs is assessed as having low research intensity ie while research may be important it does not have to occur at high levels to achieve industry or sector success. |

Results

The results of the application of the methodology are set out in the table below. These results are for the $370m scenario only. However, because the results do not included transitional factors the proportions between outputs are identical for all funding scenarios. The results incorporate the following sensitivities:

- The impact of changing the relative importance given to the three sets of goals in the Government's strategic statement. The sensitivity tested was as shown below:

| | % weighting of importance | |
|---|---|---|
| **Group of goals** | **Base assumptions** | **Sensitivity** |
| Economic | 50 | 70 |
| Environmental | 30 | 20 |
| Social | 20 | 10 |

- The impact of the changing the way the factors are aggregated. The sensitivity tested was:

  Base assumptions: Factors 1 and 6 considered to be of prime importance and directly factored into the result; Factors 2, 3 and 4 weighted together to give a single multiplier.

  Sensitivity: All factors (1, 2, 3, 4 and 6) treated as direct multipliers of equal weight.

| Output | | Base assumptions | Sensitivity to alternative weighting of goals | Sensitivity to way in which factors are aggregated |
|---|---|---|---|---|
| 1 | Animal | -- | - | -- |
| 2 | Dairy | 0 | + | ++ |
| 3 | Forage | -- | - | - |
| 4 | Hort | -- | -- | - |
| 5 | For. | - | + | 0 |
| 6 | Fishing | + | ++ | + |
| 7 | Mnfrg | 0 | ++ | 0 |
| 8 | Tourism | 0 | ++ | -- |
| 9 | Information | + | ++ | + |
| 10 | Construction | - | + | -- |
| 11 | Energy | + | ++ | - |
| 12 | Transport | ++ | ++ | -- |
| 13 | Society | ++ | ++ | -- |
| 14 | Earth | ++ | ++ | ++ |
| 15 | Land | ++ | ++ | ++ |
| 16 | Marine | ++ | ++ | ++ |
| 17 | Antarctic | ++ | ++ | ++ |

The base results show the following broad features:

- a shift of funding toward outputs with a high content of research relevant to environmental and social goals.
- a relative decline in funding for most agricultural outputs.
- broad confirmation for existing funding levels for most other outputs with an economic development focus, but with some exhibiting strong growth e.g. Transport.

The sensitivity tests run (and it is accepted that they are very limited at this stage) indicate as follows:

- irrespective of the assumptions made a persistent result is that of a reduction in funding for some agricultural outputs (animals, forage, horticulture and arable).

- an equally persistent result is that of an increase in funding for the key environmental outputs (Earth resources, Marine and atmosphere, land & water and Antarctic research.

- there is a middle group of outputs for which the broad trend is for a relative increase in funding, but this trend is dependent on and in some cases can be reversed by, the assumptions made.

## ANNEX FIVE: DETAILED DESCRIPTIONS OF PROPOSED KEY SCIENCE AREAS (KSAs)

### 1 KNOWLEDGE OF NEW ZEALAND'S BIODIVERSITY

**Definition**

The study of the land and water ecosystems in which New Zealand's fauna and flora live, including their description and naming (biosystematics).

**Purpose and Links to PGSF goals**

This KSA underpins PGSF environmental and biological production based activities. The understanding of the interlinkages and interdependencies of land and water ecosystems are important for making quality decisions on conservation and sustainable environmental management. Conservation of natural resources of biota, land and water contribute to New Zealand's international image as a nation deeply concerned about its environment.

Biosystematics is an essential component of activities focused on border control, quarantine, the Biosecurity Act, and industrial development based on new organisms.

**Estimate of existing capability**

New Zealand currently has a significant capability in ecosystem research, including maintenance of living and preserved reference collections of plants and animals and associated databases, to underpin policy development and environmental management. Given the reliance of the nation on biological materials for wealth generation and the serious threats to natural and managed ecosystems from pests, diseases, and unsustainable practices, this capability is very thinly spread.

Some limited core base skills in biosystematics covering many of the most important major groups of plants, animals, and micro-organisms are available.

**Desirable level of capability and science competencies required**

There is a need to increase the range and size of the skills base in biosystematics e.g. freshwater micro-algae and some groups of insects. There is also a need for experts in all major groups of biota in New Zealand, and for an improved understanding of the complex interactions within ecosystems.

**Development need to reach desirable level**

Collaboration between CRIs, museums and universities could identify key competencies, collections and training resources which would jointly form the core skill base needed to provide a desirable level of ecosystem understanding.

**Outputs affected by this KSA**

Directly relevant to Outputs 15-17 and cross-links to Outputs 1-8 and 13-14.

## 2 EVALUATING THE RESOURCE POTENTIAL OF NEW ZEALAND'S EXCLUSIVE ECONOMIC ZONE

### Purpose

The delineation and evaluation of the resources of New Zealand's Exclusive Economic Zone (EEZ) and the Legal Continental Shelf (LCS) to underpin effective resource management.

### Links to PGSF goals

The EEZ is 14 times larger than the New Zealand landmass and consists mostly of the continental shelf and plateaux which contain most of this country's fisheries resources, together with significant potential mineral wealth. Better knowledge of the EEZ is required to identify its economic potential and to ensure that exploitation contributes to the PGSF goals of environmental sustainability. Considerable research will be required if all interests in the resources of New Zealand's EEZ are to be balanced. These include recreation, tourism, fishing, aquaculture, environmental protection, oil and gas industries, chemicals, mining, and pharmaceuticals.

### Existing level of capability

Relevant research utilizes skills in the fields of biological, geological and physical oceanography; biosystematics; ecology; remote sensing; fisheries research; swath-mapping technology, data processing and charting; coastal engineering.

### Desirable level of capability required

Adequately resourced research groups, with a high level of knowledge of the New Zealand region and a capability to work across disciplines. There is a need for adequate seagoing facilities which fit the task, and data processing facilities and equipment, and for improved systems for identifying the environmental impacts of exploitation, with associated support staff.

### Development needed to reach the desirable level

To fully implement EEZ resource definition and environmental goals the existing level of marine science capability needs to be enhanced in many of the above areas; capability in chemical oceanography needs to be acquired and capability in marine mineral and marine geophysical evaluation needs to be restored and enhanced, especially with respect to seismic reflection acquisition, processing and interpretation in deep water.

### Outputs affected by this KSA

Outputs 6, 11, 14, 15 and 16.

## 3 NATURAL PRODUCTS FROM NEW ZEALAND'S FLORA AND FAUNA

### Purpose

To assess the natural products in New Zealand's marine and terrestrial flora and fauna for their commercial potential, and pre-commercial development of natural products including bioactive compounds.

### Links to PGSF goals

More rapid development will better realise economic and environmental goals through the identification, validation and development of new products, upgrading of waste products, the encouragement and development of local processing capability, and through enabling patents to remain under New Zealand control.

### Existing Capability and Science Competencies Required

Capabilities are needed in taxonomy; in natural product chemistry: extraction, structure solving, synthesis; in screening for evidence of bioactivity with respect to particular pharmaceutical applications, pesticides, antifouling agents, cosmetics etc.; in culture where compounds cannot be synthesised economically (agriculture, aquaculture, cell dissociation, biotechnology and tissue culture).

Some CRIs and all the universities employ organic chemists, with concentrated efforts in marine exploitation at Canterbury (in association with NIWA staff and the National Cancer Institute in the USA), and terpenes from plants at Otago and Auckland. Underpinning taxonomic study and natural product research and screening is lacking, in particular, on lesser known groups of organisms such as fungi, lichens, bryophytes, marine algae and invertebrate groups. The downstream activities relating to production of useful compounds by biological means is served by a relatively small number of scientists especially in the marine area.

### Development needed

More full-time biologists with capabilities in organism and/or tissue culture are needed to research the sustainable economic production of such compounds.
Improvement needs to be made to link chemistry results to downstream processing and utilisation objectives and in scaling up processes to a commercial level. It is currently difficult for New Zealand to hold patents, primarily because research has been funded from outside New Zealand, and various organisations have previously not been able to afford to fund the patenting process.

### Outputs affected by this KSA

The production outputs 1 - 7, and also 15 and 16.

## 4 BIOTECHNICAL METHODOLOGIES

### Expanded definition

Biotechnical methodologies include the development and application of molecular based methods to: the synthesis and analysis of genes and their products, the detection and analysis of genetic material from any source, and the production of novel products through biotechnical processes.

### Purpose and Links to PGSF goals

New Zealand's economic success will be influenced by its ability to manage its biological production systems from production to processing and export. Biotechnical methodologies will enhance the efficiency of sustainable production through the improvement of the quality, health and range of economic species and the accelerated development of existing and new, high value bioproducts.

Protection and rehabilitation of the environment (including coastal resources), sound resource management through monitoring environmental and human health, and methods of biocontrol will be enhanced by the additional management tools provided by biotechnical methods.

The accelerated growth of biotechnical methods pose potential socio-economic risks. Issues of human ethics and the long term impacts on society including negative effects on human, animal and environmental health of, for example, genetic screening, have important social consequences. Improved knowledge of the social and cultural dimensions of this KSA is important.

### Science competencies required

Fundamental and applied knowledge and skills associated with biotechnical methodologies are required in protein and DNA chemistry, recombinant DNA methods, protein and genetic engineering, biometrics, biosystematics, information sciences, bioethics and the associated disciplines of classical and quantitative genetics, biochemistry, microbiology, physiology, botany and zoology.

### Development needed to reach desirable level

Protection and enhancement of existing core competencies and expansion of core capabilities in technical and the associated disciplines, with identification of mechanisms to retain and attract young, skilled workers in the face of strong global demands. Identification of public and consumer attitudes, perceptions and expectations to prevent misdirection of science funds into sociably unacceptable endeavours.

### Outputs affected by this KSA

Primary product outputs 1, 2, 4, 5, 6, and also Outputs 7, 13, 15 and 16.

## 5 MAORI KNOWLEDGE AND DEVELOPMENT

### Expanded definition

Maintenance and development of Maori traditional knowledge to support Maori development.

### Purpose

To tap into the knowledge bases held by tribes throughout the country on the natural and physical resources in their areas. Use of this knowledge will help enhance and fill gaps in the overall base of scientific knowledge in this country, and ensure that research and development is relevant to the needs of Maoridom.

### Links to PGSF goals

The highly specialised knowledge held by a very small number of trained tribal experts in each tribe's area is a rare resource which is not currently being tapped for the benefit of the country as a whole. This KSA will directly address the PGSF goal of supporting Maori development aspirations, and ensure a greater positive contribution by Maoridom to the economy and society in general. It will also help provide a base from which to achieve the PGSF's environmental goals and meet responsibilities under the Treaty of Waitangi.

### Capability

The existing capability is very small and resides in a handful of tribal experts and probably fewer than half a dozen university scientists trained in the "western" tradition. A significantly greater number of western trained scientists with training in Maori philosophy and knowledge bases working together with tribal trained experts is required to support this KSA's objectives.

### Development Needed

The biggest current constraint is lack of acknowledgement of the existence of Matauranga Maori (Maori knowledge and philosophy). Once the acknowledgment is made and resources allocated to maintenance and development, western trained scientists need to be up-skilled in the Maori field so that the experts from the two cultures can pool their expertise for mutual benefit, produce the necessary descriptions and analyses, and continue training the next generation.

### Outputs affected by this KSA

The outputs involving primary production, society and the environment, namely Outputs 1,2 4, 5, 6, 8, 13, 14, 15 and 16.

## 6 UNDERSTANDING BIOLOGICAL HAZARDS

### Expanded definition of the KSA

Biological hazards in the widest sense: all plant and animal groups, including weeds and pathogens.

### Purpose:

To maintain competitiveness in the face of increasingly stringent demands from our markets; to protect both our productive and wilderness areas from degradation and loss of biodiversity resulting from pests; and to generally improve control of pests without compromising New Zealand's environmental standards.

### Links to PGSF Goals

Recent political and trade developments such as Gatt, international environmental conventions, and burgeoning tourist arrivals have increased the imperative for dealing with pest species if non-tariff trade barriers are to be avoided and new pest outbreaks are to be dealt with effectively.

New Zealand has internationally recognised environmental problems resulting from weed and pest species. Examples of problems in natural eco-systems are possums, rabbits, hieracium, gorse, broom, thistles and wasps. These cause significant financial loss to the agricultural sector. Given the extent of their distribution, their management is a huge problem requiring committed and long-term multidisciplinary research. Integrated pest management strategies and early interventions to identify and control potential problem pests are key requirements. New Zealand's reputation as a "clean" producer of food products must be supported by scientific data.

### Existing capability and science competencies required

Pest management is based on thorough ecological understanding and is supported by a range of multidisciplinary skills, including agronomy, ecology, parasitology, biochemistry, biometrics, economics, entomology/taxonomy, epidemiology, immunology, information science, modelling, microbiology, molecular biology, nematology, pesticide chemistry, plant pathology, reproductive physiology, soil science, toxicology and weed science.

### Desirable capability

The skill base is aging as a result of limited recruitment over the last decade. Ecological research tends not to be capital intensive and this should allow a relatively rapid rebuilding of research strength. The molecular technologies required are not uniquely different from those used elsewhere.

### Outputs affected by this KSA

Outputs 1, 2, 3, 4, 5, 8 (in particular Tourism), 13, 15 and 16.

## 7 UNDERSTANDING NATURAL PHYSICAL HAZARDS

### Definition and Purpose

To define and understand the physical hazards resulting from the processes associated with New Zealand's global position on a plate boundary, and the susceptibility of much of the economy to climatic hazards. The purpose is to equip government and industry to develop soundly-based responses, including mitigation and adaption, which will minimise effects on the New Zealand population, economy, and environment.

### Links to PGSF goals

Major physical hazards such as earthquakes and volcanic eruptions severely impact on New Zealand's social fabric, economy and environment. Similarly fires, floods and storms regularly impose significant damage. While such events cannot be avoided, the damage they cause to New Zealand's infrastructure and productive capacity can be minimised by effective research. Improvements to seasonal climate predictions, which help people and industries plan for extreme or unusual events, will have substantial economic benefits.

### Existing capability and science competencies required

New Zealand is at the international forefront of research into natural hazards and has strong links with most nations in similar settings. It contributes to and benefits from substantial international efforts in global change and climate research by the development and maintenance of relevant science capabilities. These include all aspects of geology civil engineering, atmospheric science, hydrology, ecology, modelling, information and transportation technology, economics, and social sciences.

An effective monitoring programme is essential throughout the country for all likely natural hazards (e.g. earthquake, volcanic eruption, landslide, flooding, tsunami). Much of the monitoring is currently at or below the minimal level for effective operation, while ocean and climate monitoring is limited.

There is a need for the different disciplines to meet frequently, exchange ideas and identify priorities. A commitment to long-term is desirable to allow planning for staff requirements, facilities and equipment.

### Outputs affected by this KSA

All outputs are affected in that all must bear the costs of the effects of natural physical hazards.

## 8 INTELLIGENT PRODUCTION SYSTEMS

### Expanded Definition

The development of production systems which are flexible and adaptable, facilitating short runs and high quality.

### Purpose

To ensure that the adoption of intelligent production systems by New Zealand's particular mix of internationally competitive industries is as rapid and successful as possible. "Manufacturing" includes primary production and processing, as well as secondary industries. Many of our industries rely on biological materials which are much more complex and harder to handle than, say, components for car assembly. We therefore face special challenges.

### Link to PGSF Goals

Major contribution to PGSF economic goals by enhancing quality, enabling a optimal exploitation of niche markets, and contributing to a value-added export strategy. Social goals will be enhanced by the empowering nature of the workplace reform which goes hand in hand with best practice uptake of flexible manufacturing systems and a focus on quality. Environmental goals are addressed through greater production efficiency and an overall trend towards low-volume high-value products.

### Science competencies required

The scientific and technological requirements of such systems include advanced sensor technologies, multi-dimensional information processing, knowledge engineering, control systems theory, systems modelling, human-computer interface design, end-effector and robotics technologies and artificial intelligence.

Expertise in many of the component specialties is well developed. What is needed most is for this knowledge to be focused on whole working systems, and developed into useful technological and engineering systems. Devising intelligent manufacturing systems involves close interaction between researchers and industry, with many iterations of the research/ design/ prototype loop. It is desirable that teams of researchers, technologists and engineers from research institutions and private industry work together to develop generic expertise (in the form of identified research groups and consultants) as well as specific working manufacturing systems to act as demonstration models.

### Outputs affected by this KSA

All product processing outputs: 1, 2, 4, 5, 6, 7. Also Outputs 8, 9 and 13.

## 9 IMPROVED PROCESSING TECHNOLOGIES

### Expanded Definition and Purpose

Technologies are needed to lift the proportion of mainstream New Zealand commodities processed before export. On-shore processing of our major exports (timber, milk, wool, meat, skins, grains, crops, animal by-products) is often not economically viable if we use imported, off-the-shelf processing systems also available to lower labour cost countries. Large horizontal early stage processing industries can develop around unique New Zealand processing know-how (wool scouring, cheese making, pulp, flour making, fats). Smaller niche processing options exist to take local raw materials right through to consumer products for export (tissues, croissants, tourist items in wool, spreadable butter, pharmaceutical products).

### PGSF Goals

The main impact is on economic goals with spin offs for social goals via a more competitive society with high value adding jobs.

### Existing capability

The science and technology requirement tends to be product and industry specific, as we are looking for niche technologies for conversion of products in which New Zealand has a dominant supply position globally. Key resources include FRI, DRI, MIRINZ, WRONZ, IRL, Crop and Food, and some university departments.

Capacity in these "added value" organisations will need to be significantly enhanced if New Zealand is to develop competitive clusters around its core products.

### Outputs affected by this KSA

Outputs actively involved in processing include Outputs, 1, 2, 4, 5, 6, and 7.

## 10 CLEAN PROCESSING AND MANUFACTURING TECHNOLOGY

### Expanded Definition

Technologies to assist manufacturing and exporting industries to reduce their environmental impacts without loss of conversion efficiency.

### Purpose

International pressures are continually lifting the requirements for New Zealand manufacturing industries to be clean with respect to environmental impact. The post-GATT trading environment will see increasing attempts by foreign domestic producers of goods that compete with our export products, to raise non-tariff barriers against New Zealand goods. This issue is reinforced by the tightening Resource Management Act requirements. The competitive advantage of many New Zealand industries is at stake unless they have technological solutions to their waste creation and disposal. Metal ions, dyestuffs, chemicals, grease, packaging and other pollutants all require specialist abatement and clean up technologies many of which are specific to New Zealand conditions.

### Goals

In the proactive sense this KSA will deliver on most environmental goals covering the manufacturing sector. However, there is also a defensive goal vis-a-vis most of the economic goals and to protect social cohesion.

### Existing capability

Existing capability is substantial with skills spread over most CRIs, Research Associations and the universities.

### Desirable capability

Any scale up needed will be easily achieved.

### Outputs affected by this KSA

Primarily the processing outputs: 1, 2, 4, 5, 6, 7, but also 10, 11, 12, 13, 15 and 16. Linked KSAs are Biological Hazards Management, Processing Technology, and Sustainable Biological Production Systems.

## 11 SUSTAINABLE BIOLOGICAL PRODUCTION SYSTEMS

### Purpose and Links to PGSF goals

To identify the biophysical limits that underpin sustainable management of land, forests, fisheries and energy. As well as minimizing production system impacts on resources and the environment, this Key Science Area would seek to ensure that New Zealand's export potential in food and fibre products is realised by meeting the demands from our markets for a clear demonstration of the sustainability of our production systems and a commitment to animal welfare.

New Zealand has some internationally recognised environmental problems resulting from ill-advised land use e.g. degradation of high country landscapes, soil instability of North Island hill country and agrochemical residues and run-off. These negative features in New Zealand need to be addressed.

Chemophobia and the impacts of production systems on the quality of our soil, air and water is a source of increasing concern. Many current environmental quality concerns coincide with Maori cultural values. As people decide what happens to the environment through individual or collective actions, social research is a key requirement.

### Existing capability and science competencies required

Sustainable production is ecologically based and requires multidisciplinary skills such as agronomy, animal ecology, animal production, biometrics, farm systems, understanding legislation (both national and international), taxonomy, information science, market surveillance microbiology, molecular biology, pasture ecology, pest management, plant ecology, remote sensing, soil science and water management.

New Zealand has perhaps 500 scientists/technicians active in land based production research, many of whom focus on developing sustainable production systems. Contracting funding in recent years has led to a severe reduction in sustainable research capability over the last 10-15 years. There has been very little recruitment of new scientists in the last 10 years; the skills base is therefore aging.

### Desirable capability

Research into sustainable production involves integrating production and conservation systems. There is a need for researchers to adopt those integrating policies and to coordinate their activities between research providers.

### Outputs affected by this KSA

The objective of this KSA is fundamental to the productive outputs: 1, 2, 3, 4, 5, 6, 7, and to 11, 13, 15 and 16.

## 12 SOCIAL EQUITY

The panel wishes to develop a KSA which recognises the cross-output potential of the social goals for the PGSF, particularly the first two goals described in the Government's Strategic Statement: Science & Technology: The Way Forward. Accordingly it invites submissions which would facilitate this, based on those goals. The goals are reproduced here:

**Social Goals**

- Improve understanding of key issues affecting acquisition of skills and knowledge necessary for full engagement of individuals in the economy and society.

- Improve knowledge of the social and cultural dimensions and trends of a competitive economy.

## ANNEX SIX: BIBLIOGRAPHY OF INFORMATION CONSIDERED

In addition to output reports received from convenors, stakeholder submissions and the result of the Delphi survey, the SPiR also considered the following documents:

| Title | Agency |
|---|---|
| Appropriability and the Public Good Science Fund | Ministry of Research, Science and Technology |
| The appropriability of R&D | Foundation for Research, Science and Technology |
| Analysis of GDP contribution by output | Infometrics, NZ Institute of Economic Research |
| Background information for the Science Priorities Statement | Foundation for Research, Science and Technology |
| The capability of research providers as determined by applications to the PGSF | Foundation for Research, Science and Technology |
| Comparison of actual and projected implementation of PGSF priorities | Ministry of Research, Science and Technology |
| Environment 2010 Strategy | Ministry for the Environment |
| Evaluation of the Process Used in 1992 to Set Priorities for the PGSF | Ministry of Research, Science and Technology |
| GATT: A big deal for NZ agriculture | MAF Information Bureau |
| Inter-industry transactions 1990/91 | NZ Institute of Economic Research |
| Long Term Sectoral Forecasts | NZ Institute of Economic Research |
| Manufacturing for Growth 1995 | Manufacturing Advisory Group |
| Mapping of 1993/94 research strategy funding trends to the 17-Output Framework | Foundation for Research, Science and Technology |

| Title | Agency |
|---|---|
| Methodologies for priority-setting | AgResearch, Agriculture Canada, Crop and Food CRI, CSIRO (Australia)Dr Grant Scobie, Ministry of Commerce, Ministry for the Environment, Ministry of Research, Science and Technology, The Treasury |
| NZ's Economy - Some Long Term Issues, December 1993 | Infometrics |
| NZ's Economy - Some Long Term Issues, December 1994 | Infometrics |
| PGSF research contracts 1994/95; proposed allocations to 17-output framework | Foundation for Research, Science and Technology, Ministry of Research, Science and Technology (jointly) |
| Quarterly Predictions - December 1994 | NZ Institute of Economic Research |
| Report on parallel process of consulting with Maori | Terry Lomax |
| Science & Technology: The Way Forward 1996-2001 | NZ Government |
| "Stretching for Growth" | TRADENZ |

## ANNEX SEVEN: LIST OF SPIR MEMBERS

### Convenor

| | |
|---|---|
| Doug Wright | Science consultant. Recently retired as Director of the Meat Industry Research Institute of New Zealand (MIRINZ). In 1993, acted as a consultant to FRST to develop a Science Area Research Strategy for sheep and beef production and processing research. Current Convenor of the National Science Strategy Committee on Possum and Bovine Tuberculosis Control. |

### Members

| | |
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| Helen Anderson | Director of Earth and Ocean Sciences Research, a joint venture between the Institute of Geological and Nuclear Sciences and the University of Otago. Member of STEP 1992. Fulbright scholar. PhD in seismology and researcher in the mechanics of large earthquakes in the New Zealand region. |
| Alan Bollard | Chairman, New Zealand Commerce Commission, Research Associate, New Zealand Institute of Economic Research, Chair, New Zealand Institute for Social Research and Development Ltd, former member of Science and Technology Advisory Committee (STAC) Review Panel. PhD in economics. |
| Murray Gough | Formerly Chief Executive, New Zealand Dairy Board and a director of the Dairy Research Institute. Now Director of New Zealand Kiwifruit Marketing Board, AMP Society, New Zealand Rural Properties Ltd, Tui Milk Products Ltd, Forestry Corporation, ANZCO and Sealord. Academic qualifications in Commerce and significant experience in international marketing and information technology. |
| Peter Jackson | Professor and Head of the Department of Mechanical Engineering at Auckland University. Research interests primarily in yachts, wind engineering and low-speed aerodynamics. Wide experience in consulting and R&D for local industry, including involvement with all four NZ challenges for the Americas Cup. Member of the Engineering and Technology Committee of the NZ Institute of Professional Engineers. |
| Andrew Matthews | Manager of the NIWA Laboratory at Lauder in Central Otago. Has a PhD in Physics and is actively involved in ozone depletion research. A member of a number of international science committees organising global change research using ground based as well as satellite technologies. |
| Murray Milner | General Manager, Fundamental Planning, Telecom. PhD in telecommunications engineering. His career has included a period working with a British telecommunications equipment manufacturer. Harkness Fellow to the United States. Present duties involve |

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| | managing a team in assessing developments and selecting appropriate technologies and equipment for incorporation in Telecom's network, with a focus on the longer-term. |
| Wendy Nelson | Scientist/collection curator, plants, Museum of New Zealand. PhD, eminent biosystematist specialising in marine algae. She has also worked on commercial projects and in management at MAF Fisheries, is a member of the Royal Society Standing Committee on Marine Sciences, a committee member of the Association of Women in Science and member of numerous scientific societies. |
| Papaarangi Reid | A senior lecturer/researcher at the Wellington Medical School. Specialist in public health medicine, with extensive experience in health promotion. Member of Ministerial enquiry into assisted reproduction technology and board member of Maori Heartbeat (National Heart Foundation). |
| Neil Richardson | Group Managing Director of Gallagher Group Limited, leader in power fencing for agricultural and security applications. Over a decade of marketing and general management responsibilities in Australia, the UK and USA. Over a decade as a management consultant in Australia, with a wide range of international clients across many industry sectors. Academic appointments over the past twenty years at three universities in Australia and the USA, combining teaching and research and marketing, law and innovation. Holds Bachelors and Masters degrees in Marketing and a Juris Doctor Degree in Business Law. |
| Graeme Robertson | Chief Executive Officer, Cawthron Research Institute. President of the Institution of Professional Engineers. Graduate in Chemical Engineering, has worked in the pulp and paper industry in New Zealand and Sweden. |

## ANNEX EIGHT: LIST OF CONVENORS AND SUBCONVENORS

Key = (1) Convenor
(2) Sub-Convenor

| Output | | Name | | Agency |
|---|---|---|---|---|
| 1 | Animals | (1) | Brian Chrystall | Meat Industry Research Institute of NZ |
| | | (2) | Peter Brumby | Farmer |
| 2 | Dairy | (1) | David Johns | NZ Dairy Board |
| | | (2) | Kevin Marshall | NZ Dairy Research Institute |
| 3 | Forage | (1) | John Lancashire | AgResearch Ltd |
| | | (2) | John McKenzie | Agricom NZ Ltd |
| 4 | Hort & Arable | (1) | Jim Kerr | Independent Consultant |
| | | (2) | Bob Martin | NZ Kiwifruit Marketing Board |
| 5 | Forestry | (1) | Colin O'Loughlin | Independent Consultant |
| | | (2) | Ken Shirley | NZ Forest Owners Assn |
| 6 | Fisheries | (1) | Royce Elliot | NZ Institute of Public Administration |
| | | (2) | Denis Thomas | Sealord Products Ltd |
| 7 | Manufacturing | (1) | Denis Malone | Industrial Research Ltd |
| | | (2) | John Hellström | Mallinckrodt Veterinary Ltd |
| 8 | Services | (1) | Paul Winter | NZ Tourism Industry Assn |
| | | (2) | Jean Fraser | Tradenz |
| 9 | Information | (1) | David Bibby | Industrial Research Ltd |
| | | (2) | Tony Tait | ITANZ |
| 10 | Construction | (1) | John Duncan | BRANZ |
| | | (2) | Bill Robinson | Industrial Research Ltd |

| Output | Name | Agency |
|---|---|---|
| 11 Energy | (1) Kevin Duckworth | Industrial Research Ltd |
| | (2) John Blakeley | Centre for Advanced Engineering |
| 12 Transport | (1) Peter Goodwin | Chartered Institute of Transport in NZ |
| | (2) Jim McMillan | Transit New Zealand |
| 13 Society | (1) Margaret Shields | Independent Consultant |
| | (2) Mason Durie | Massey University |
| 14 Earth | (1) Ian Graham | Institute of Geological & Nuclear Sciences |
| | (2) John Pfahlert | NZ Minerals Industry Assn. |
| 15 Land & Water | (1) David Penman | Landcare Research Ltd |
| | (2) Paul Mosley | Victoria University |
| 16 Marine & Atmosphere | (1) Rick Pridmore | NIWA |
| | (2) David Wratt | NIWA |
| 17 Antarctic | (1) Fred Davey | Institute of Geological & Nuclear Sciences |
| | (2) Clive Howard-Williams | NIWA |

## ANNEX NINE: EXPERT WORKING GROUP MEMBERS

**Convenor**

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|---|---|
| Dr Andrew Matthews | SPiR |

**Members**

| | |
|---|---|
| Dr Augie Auer | Meteorological Service of NZ |
| Dr John Butcher | Forest Research Institute Ltd |
| Dr Garth Carnaby | Wool Research Organisation of New Zealand |
| Dr Andrew Cleland | Massey University |
| Professor Jim Cole | University of Canterbury |
| Dr Steve Goldson | Agresearch |
| Dr Janet Grieve | National Inst. of Water & Atmospheric Research Ltd |
| Jim Higgins | World Communication Laboratory |
| Professor Stuart McCutcheon | Massey University |
| Dr Ken McNatty | Wallaceville Animal Research Centre |
| Assoc Prof John Montgomery | University of Auckland |
| Dr Margaret Mutu | University of Auckland |
| Dr Murray Parsons | Landcare Research Ltd |
| Dr Bob Wyn-Williams | Crop & Food Ltd |

## ANNEX TEN: LIST OF STAKEHOLDER SUBMISSIONS RECEIVED

| | |
|---|---|
| AgResearch | Bill Kain |
| AgResearch | Rob Pringle |
| Alex McDonald (Merchants) Ltd. | C A McDonald |
| Association of Social Science Researchers | Dr Allan Levett |
| Association of Social Science Researchers | Dr Allan Levett |
| AS Wilcox and Sons Ltd. | A G Wilcox |
| Australian Institute of Mining and Metallurgy | L S Jones |
| Carter Holt Harvey Forest | Bill Dyck |
| Coal Research Ltd. | R S Whitney |
| Crop and Food Research | M W Dunbier |
| Department of Internal Affairs | R A Stockdill |
| Department of Mechanical Engineering, University of Canterbury | Dr Roger Green |
| ECNZ | Stephen Wilce |
| Energy Efficiency & Conservation Authority | Stephen Thornton |
| Environment Waikato Staff | K M Ennis |
| ENZA New Zealand (International) | Gisela Ahlborn |
| Federated Farmers | Helen Agnew |
| Federated Farmers | Helen Agnew |
| Federated Farmers Dairy Section | Catherine Beard |
| Federation of New Zealand Social Sciences Organisations | Assoc. Prof. Paul Spoonley |
| FRSNZ, FNZIAS | A H Kirton |
| Geoscience Research and Investigations New Zealand | Dr Gerrit J van der Lingen |
| Geosciences Standing Committee, RSNZ | S D Weaver |
| HortResearch | James Buwalda |
| Independent Submission | Fred Davey |
| Independent Submission | Laurence Huggard |
| Independent Submission | Jim Kerr |

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|---|---|
| Industrial Research | Geoff Page |
| Industrial Research | J B Meikle |
| Industrial Research Ltd. | P J Connor |
| Information Technology Association of New Zealand | Tony Tait |
| Landcare Research | P B S Hart |
| Logging Industry Research Association | John Gaskin |
| Macraes Mining Company Ltd. | Angus Kennedy-Perkins |
| Manufacturing Advisory Group | D Galwey |
| Meat Industry Research Institute of New Zealand (Inc) | G R Longdell |
| Meteorological Society of New Zealand | Dr Jim Salinger |
| Ministry for the Environment | R Blakeley |
| Ministry of Commerce | Joe Manning |
| Ministry of Foreign Affairs and Trade | David Gamble |
| Ministry of Forestry | Mary Clarke |
| Ministry of Women's Affairs | Judy Lawrence |
| Museum of New Zealand | Dr Janet Davidson |
| Museum of New Zealand | Mark Fell |
| National Innovation Centre Ltd | Steve Flynn |
| New Zealand Antarctic Programme | Gillian Wratt |
| New Zealand Archaeological Association Inc | Moira White |
| New Zealand Asparagus Council | Lesley McKeown |
| New Zealand Association for Research in Education | Stuart McNaughton |
| New Zealand Association for Research in Education | Stuart McNaughton |
| New Zealand Association of Scientists | Michael Berridge |
| New Zealand Buttercup Squash Council Inc. | John Brakenridge |
| New Zealand Deer Industry | Richard Riddiford |
| New Zealand Fishing Industry Board | Andrew Branson |
| New Zealand Flour Millers Association Inc. | Michael Smith |

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|---|---|
| New Zealand Food and Beverage Exporters' Council Inc. | Melissa Hodd |
| New Zealand Forest Industries Council | James Griffiths |
| New Zealand Forest Research Institute | John A Butcher |
| New Zealand Forest Research Institute Ltd. | Dr Frank Wood |
| New Zealand Historical Association | M P K Sorrenson |
| New Zealand Institute of Agricultural Science | Howard Bezar |
| New Zealand Institute of Building Inc. | Dr W A Porteous |
| New Zealand Institute of Economic Research (Inc.) | John Yeabsley |
| New Zealand Institute of Surveyors | Prof. John Hannah |
| New Zealand Leather and Shoe Research Association | Tony Passman |
| New Zealand Leather Industry | John Nimmo |
| New Zealand Kiwifruit Marketing Board | Bob Martin |
| New Zealand Manufacturers Federation Inc. | Simon Arnold |
| New Zealand Marine Sciences Society | Elisabeth Slooten |
| New Zealand Meat Research and Development Council | Alan Royal |
| New Zealand Plant Breeding and Research Association (Inc.) Output 3 | Kerry Arnold |
| New Zealand Plant Breeding and Research Association (Inc.) Output 4 | Rod East |
| New Zealand Plant Protection Society (Inc.) | Dr R E Falloon |
| New Zealand Protea Growers Association | Peter Altham |
| New Zealand Racing Industry Board | J R Alexander |
| New Zealand Tree Crops Association | Eric Cairns |
| New Zealand Truffle Association Inc. | Annie Bowker |
| New Zealand Vegetable and Potato Growers' Federation Inc. | |
| Parliamentary Commissioner for the Environment | Helen Hughes |
| PCM Solectric Co. Ltd. | Trisha Mierzejewski |

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| Petroleum Exploration Association of New Zealand (Inc.) | David Crawford |
| Possum and Bovine Tuberculosis Control National Science Strategy Committee | Sharon Foss |
| Ross Dependency Research Committee | Clive Howard-Williams |
| Royal Society | Prof. P M Black |
| Sealord | Dennis Thomas |
| Sealord Products Ltd. | Dennis Thomas |
| Standing Committee on Primary Production Sciences and Technologies | Brian Balshaw |
| Systematic Association of New Zealand | Dr Adrian Paterson |
| Tainui Maori Trust Board | R T Mahuta |
| Technicrop Pacific Ltd | Hugh Steadman |
| Te Puni Kōkiri | Neil McInnes |
| Te Puni Kōkiri | Haami Piripi |
| Te Puni Kōkiri | Glenn Webber |
| Tourism Research Working Group | K Huse |
| Turners and Growers Ltd. | D M Brown |
| University of Auckland | Prof. David Gauld |
| University of Kent, UK | Charles Crothers |
| Victoria University | M P Mosley |
| Victoria University | |
| Wine Growers of New Zealand | Philip Gregan |
| Wool Industry | Dr Grant Sinclair |

## ANNEX ELEVEN: LIST OF KEY SCIENCE AREA SUBMISSIONS RECEIVED

| | |
|---|---|
| AgResearch | W M Kain |
| AgResearch | Ian Popay |
| Asian New Zealand Meat Company Ltd. | Dr Robert Archibald |
| Auckland University | |
| Biochemistry Dept, University of Otago | Dr Diana Hill |
| Building Research Assn | A D Nichols |
| Carter Holt Harvey | Bill Dyck |
| Crop and Food Research | M W Dunbier |
| Dairying Research Corp. | K E Jury |
| Department of Agricultural Engineering, Massey University | Ralph Sims |
| Department of Chemistry, Auckland University | Prof C J O'Connor |
| Department of Geography, Victoria University | M P Mosley |
| Department of Geology, University of Canterbury | Prof. J W Cole |
| Department of Physics and Astronomy, University of Canterbury | Prof. G E Stedman |
| Department of Social Welfare | Linda Allan |
| Department of Surveying, University of Otago | |
| Earthquake Commission | Ian McLean |
| Environment Waikato Regional Council | K M Ennis |
| Faculty of Agricultural & Horticultural Science, Massey University | Prof. John Hodgson |
| Federated Farmers (Dairy section) | Catherine Beard |
| Geological Society of New Zealand | Ian E M Smith |
| Geology Department, University of Auckland | P M Black |
| Geology Department, University of Canterbury | Dr M G Laird |
| HortResearch | James Buwalda |
| Independent submission | Harold V Henderson |

| | |
|---|---|
| Independent Submission | Laurence Huggard |
| Independent submission | Dr N Perry |
| Industrial Research | |
| Industrial Research | J B Meikle |
| Industrial Research | J B Meikle |
| Industrial Research | Howard Nicholls, P J Connor |
| Industrial Research Ltd. | Dr D R Crump |
| Industrial Research Ltd. | D K W Smith |
| Institute of Geological and Nuclear Sciences | Dr David Ross |
| Institute of Geological and Nuclear Sciences | Dr V John Varcoe |
| ITANZ | Tony Tait |
| Landcare Research | Dr Jeff Weber |
| Mathematical & Info Sciences Council | Prof. G C Wake |
| Meat Industry Research Institute of New Zealand | G R Longdell |
| Meteorological Society of New Zealand | Dr Jim Salinger |
| Ministry for the Environment | R W G Blakely |
| Ministry of Commerce | Energy & Resources Division |
| Ministry of Foreign Affairs and Trade | David Gamble |
| Ministry of Women's Affairs | Dr Judy Lawrence |
| Museum of New Zealand | Cheryll Sotheran |
| National Library of New Zealand | P G Scott |
| New Zealand Archaeological Association | Moira White |
| New Zealand Association for Research in Education | Stuart McNaughton |
| New Zealand Association of Scientists | Michael V Berridge |
| New Zealand Dairy Research Institute | Dr T D Thomas |
| New Zealand Forest Research Institute | Dr Frank Wood |
| New Zealand Geophysical Society Inc. | Dr John Taber |
| New Zealand Institute of Agricultural Science | Howard Bezar |

| | |
|---|---|
| New Zealand Marine Sciences Society | Dr Elisabeth Slooten |
| New Zealand Manufacturers Federation | Simon Arnold |
| New Zealand Mathematical Society | Prof. M D E Conder |
| New Zealand Meat Research & Development Council | Dr Alan Royal |
| New Zealand National Society for Earthquake Engineering | John H Wood |
| New Zealand Plant Breeding and Research Assoc | L J Dick |
| New Zealand Plant Protection Society | Dr Richard Falloon |
| New Zealand Plant Protection Society | Dr R E Falloon |
| NIWA | |
| Possum and Bovine Tuberculosis Control National Science Strategy Committee | Sharon Foss |
| Pu Hao Rangi Trust | Tai Kareroa |
| Research School of Earth Sciences Institute of Geophysics, Victoria University | Prof. Euan Smith |
| Royal Society of New Zealand | Dr Judy Lawrence |
| Royal Society of New Zealand | S M Usher |
| Royal Society of New Zealand | Dr David Wratt |
| Social Anthropology and Maori Studies, University of Auckland | Prof. Anne Salmond |
| Strategic Consultative Group on Sustainable Land Management Research | Basil Chamberlain |
| Systematic Association of New Zealand | Dr Adrian Paterson |
| Te Puni Kōkiri | |
| Te Puni Kōkiri | Neil McInnes |
| Te Puni Kōkiri | Neil McInnes |
| Te Wananga O Raukawa | Whatarangi Winiata |
| TRADENZ | Jean Fraser |
| Victoria University | |
| Wool Research Organisation of New Zealand | A J McKinnon |

# PGSF OUTPUT DEFINITIONS
# 17 OUTPUT FRAMEWORK

*The output definitions expressed below are broad statements of purpose, rather than detailed taxonomies of the nature of research in each output. It is the role of the Foundation for Research, Science and Technology to provide detailed descriptions of the science and technology funded in each output to assist those making bids for funds. The PGSF does not fund the research which government departments undertake in order to carry out their operational functions. The italicised comments below output definitions are not a formal part of the definitions but are intended to assist in their interpretation. Although the comments provide examples of research included in each output, research is not limited to only the examples given.*

## 1. Animal Industries

Science and technology contributing to innovative and efficient industries focused on (non-dairy) animals, including science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included are science and technology related to the sheep, beef, equine, deer, goat, poultry and pig industries, but not excluding other animal industries that may exist or emerge. Research may contribute to a specific industry sector, or be of a generic, underpinning nature. Research specific to the social dimensions and information needs of the industry may be included.*

## 2. Dairy Industries

Science and technology contributing to an innovative and efficient dairy industry, including science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included are science and technology related to all aspects of the dairy industry. Research specific to the social dimensions and information needs of the industry may be included.*

## 3. Forage

Science and technology focused on the production of the high-quality and low cost forage needed by New Zealand's pastoral industries, including science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included are science and technology related to forage seed propagation, and the study of fertilisers, soils, and landform processes relevant to New Zealand's pastoral agriculture industries. Research specific to the social dimensions and information needs of the industry may be included.*

## 4. Horticultural, Arable and Other Food and Beverage Industries

Science and technology contributing to innovative and efficient horticultural, arable and other food and beverage industries, as well as industry activities focused on the growing of ornamental, amenity, shelter and conservation plants. Also included is science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included is science and technology related to the production, processing and transporting of foods. This includes, but is not restricted, to science and technology related to: stone, pome and citrus fruits, grapes, vegetables, nuts, edible fungi, cereal crops, oilseeds and grain legumes; seed and other propagation methods of species associated with these industries, and the study of soils used or associated with the above purposes. Research specific to the social dimensions and information needs of the industry may be included.*

## 5. Forestry and Forest Product Industries

Science and technology contributing to innovative and efficient forestry and forest product industries. Also included is science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included is science and technology related to both exotic and indigenous plantations and systems; the protection of the forest estate; species and provenance testing and tree improvement research; forest nutrition and site productivity; seed and other propagation methods associated with the industry sector; development of systems for the evaluation of management alternatives; the processing of wood for production of solid wood products and pulp and paper. Research specific to the social dimensions and information needs of the industry may be included.*

## 6. Fishing and Aquaculture Industries

Science and technology contributing to innovative and efficient fishing and aquaculture industries, including science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included is science and technology related to enhancement and harvesting of natural fish stocks; the harvesting, processing and transportation of aquatic plants, fish, shellfish and crustaceans; customary fisheries; as well as all aspects of the aquaculture industry. Research specific to the social dimensions and information needs of the industry may be included.*

## 7. Manufacturing Industries and Industrial Technology

Science and technology contributing to innovative and efficient manufacturing industries, including science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included are science and technology related, but not limited to: electronics; computing; agricultural and industrial chemicals; pharmaceuticals and other high value biotechnological products; fabricated metal products; textiles; leathergoods; footwear; and apparel. Research may be aimed at a specific industry sector, or may be aimed at a broad range of manufacturing and processing industries. Research specific to the social dimensions and information needs of the industry may be included.*

## 8. Tourism, Commercial and other Services

Science and technology contributing to innovation and growth in the tourism, leisure, financial, business, retail, trade and other service industries, and including science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society. Research specific to the social dimensions and information needs of the industry may be included.

## 9. Information & Communications Networks and Services

Science and technology contributing to information and communications infrastructures which meet the needs of New Zealanders directly and indirectly, including science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society. Research specific to the social dimensions and information needs of the industry may be included.

*Information technology that is an input into other industries should be funded within the appropriate output class for that benefiting industry.*

## 10. Construction

Science and technology contributing to construction industries and services which meet the economic, social and environmental goals of New Zealanders. Also included is science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included is science and technology related to materials and products including stone and clay, cement and concrete, and construction using glass, timber, metal products and plastics; construction, planning and design, products and services including earthquake engineering for residential, non-residential, civil and industrial construction including road and bridge engineering and construction. Research specific to the social dimensions and information needs of the industry may be included.*

## 11. Energy

Science and technology focused on energy extraction, conversion, distribution and management aimed at meeting the economic, social and environmental goals of New Zealanders. Also included is science and technology oriented towards understanding and ameliorating the impacts of industry activities on the natural environment and on society.

*Included is geological research that has as its primary purpose the development of viable energy resources. Other geological research where benefits diffuse more widely should be funded from the Earth Resources Output. Research specific to the social dimensions and information needs of the industry may be included.*

## 12. Transport and Distribution Systems

Science and technology contributing to an infrastructure of transport/storage/distribution systems and services aimed at meeting the economic, social and environmental goals of New Zealanders and New Zealand enterprises. Also included is science and technology oriented towards understanding and ameliorating the impacts of transport and distribution systems on the natural environment and on society.

## 13. Society and Culture

Science and technology contributing to the social wellbeing, national identity, and security of New Zealanders, and to the development of international understanding.

*Included is science related to: New Zealand and Pacific history; population demographics; Te Ao Maori; the Treaty of Waitangi; aspects of New Zealand culture and society. Also included is science related to: government, public administration and political processes, justice, law and human rights; the New Zealand economy and its dynamics; work, working relationships and labour markets; employment and working conditions; wealth generation and distribution; international relations; urban and rural planning; and the social and cultural implications of economic and political change. Science related to education and training processes; research and knowledge production; the management and communication of knowledge; and the social and cultural implications of knowledge change are also included in this output.*

## 14. Earth Resources and Processes

Science and technology focused on the structure, composition, geological history and physical processes relevant to New Zealand's unique geological setting, and an understanding of the causes, consequences and mitigation of natural and man-made hazards.

*Included is the identification and assessment of: mineral and subsurface water resources, and earth resources research that feeds into multiple outputs; geological influences on the environment, human habitation and global change; and deeper sediments in aquatic environments.*

## 15. Land and Fresh Water Eco-systems

Science and technology contributing to the understanding of land, and freshwater eco-systems, and to the analysis and amelioration of the environmental impacts of social development and economic activities.

*Included is science and technology related to: the physical, chemical and biological properties and potential uses of New Zealand's lands and soils, the native and introduced flora and fauna, and the ecosystems of which they are a part; freshwater eco-systems, and their underlying substrate, flora and fauna; and the environmental planning of urban and rural areas. Also included is science and technology focused on reducing the impacts of human and other activity on the natural environment. This excluded science and technology focused on ameliorating the impacts of industry or other human activity that is specific to a sector aligned output.*

## 16. Marine Environments, Climate and Atmosphere

Science and technology contributing to the understanding of marine and estuarine eco-systems, the climate and atmosphere, and to analysis and amelioration of the environmental impacts of social development and economic activities.

*Included is science and technology related to: the physical, chemical, and biological processes and characteristics of the marine waters of New Zealand, and their underlying substrate, flora and fauna; and the atmosphere, climate, the interaction of the atmosphere with the hydrosphere and biosphere. Also included is science and technology related to the amelioration of the impacts of human and other activities on marine environments, the climate and atmosphere.*

## 17. Antarctic Research

Science and technology focused on the physical and biological nature of Antarctica, including the geology, natural ecosystems and climate.

*Included is all science and technology physically carried out in Antarctica, including social research.*